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INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	jĭ'ga	
10^{6}	mega	mĕg'a	
10^{3}	kilo	kĭ'lo	
10^{2}	hecto	hĕk'to	
10	deka	dĕk'a	
10^{-1}	deci	dĕs'i	
10^{-2}	centi	sĕn'ti	
10^{-3}	milli	mĭl'i	
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
A	ampere(s)	
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps-2.22×10^{12} dpm
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	3.527×10^{-2} ounces= 2.205×10^{-3} pounds
Hz	hertz	cycle per second
kVp	kilovolt peak	
m	meter(s)	39.4 inches
m^2	cubic meter(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
mi	mile(s)	
ml	milliliter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g
s	second	

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Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

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U.S. ENVIRONMENTAL PROTECTION AGENCY

Russell E. Train, Administrator

Reports

Evaluation of Uranium Mine Atmospheres by Measurements of the Working Level and Radon

Duncan A. Holaday and James H. Jones[1]

Using estimates of equilibrium ratios and concentrations of unattached atoms in uranium mines, calculations were performed and results presented of the amount of alpha energy per liter of air per working level available to be imparted to the various regions of the respiratory tract. It was discovered that the factor that caused the greatest effect on the alpha energy that could be deposited in the lungs was a change in the unattached fraction of the radon daughters. If the radon concentration was used to determine potential exposure, radon to daughter ratios also had a marked effect on the potential alpha energy deposition.

The primary radiation health hazards in uranium mines are created by radon-222 and its short-lived daughters, polonium-218 (RaA), lead-214 (RaB), bismuth-214 (RaC) and polonium-214 (RaC′). In almost all mining situations, the hazard from radon is believed to be negligible compared to that produced by the airborne daughters, so methods of evaluating mine atmospheres have been directed towards estimating concentrations of the daughters. Ideally, measurements should be made of radon, each individual daughter, the concentration and size distribution of particulates, and the fractions of each daughter which exist as "free atoms." In practice, two procedures have been used in control programs, (1) measurements of radon and (2) measurement of the potential alpha energy of the daughters, based on the assumptions that approximately the same fraction of each would be deposited in the respiratory tract with similar distributions in the various parts of the lung and that most of the daughters which were deposited in the lung decayed to lead-210 (RaD) before clearance. It was recognized that both of these assumptions are only approximately true.

A number of studies have been reported in which the radiation dose to the lung from alpha particles was calculated using a variety of hypothetical mine atmospheres and several lung models which show that there is no constant ratio between working levels and rads. The variations in the calculated ratios are large when extreme conditions are considered, such as equilibrium ratios of RaA:RaB:RaC = 1:1:1 and RaA:RaB:RaC = 1:0:0 with fractions of unattached atoms varying from 1 to 0. These studies raise serious questions of the suitability of use of measurements of the working level for control purposes. Measurements of radon followed by estimation of daughter concentrations and fractions of free atoms could be used if conditions were relatively stable. Conditions in mines, however, may vary widely from hour to hour. The same variations will also alter the validity of working level (WL) measurements.

Effect of radon daughter equilibrium ratios and fractions of free atoms in lung dose calculations

Two in-depth reviews of the subject of lung dosimetry are available: those of Nelson, et al. (*1*) and Walsh (*2*). Nelson concluded that the fractions of free atoms were a more important parameter in affecting dose than were the relative proportions of daughters, for the hypothetical atmosphere which they considered. Walsh also concluded that

[1] Mr. Holaday was and Mr. Jones is with the Division of Field Studies and Clinical Investigations, NIOSH, Salt Lake City, Utah. Mr. Holaday is retired.

the relative concentrations of RaA, RaB, and RaC were not important because most of the radiation dose is due to RaC′ alphas. Walsh considered that for continuous exposure the mean elimination rate for radon daughters is much longer than the physical half-life and although radon daughters may not decay at the site of deposition, they will in the long run be replaced by atoms which will decay there, so there is effectively little clearance from the lung. The fractions of uncombined RaA, RaB, and RaC, however, were important in determining lung radiation dose.

Existing conditions in American mines

An extensive and intensive study of the radiological characteristics of uranium mine atmospheres was reported by Breslin, George, and Weinstein (*3*). As part of this work, mean daily radon daughter equilibrium ratios were determined in 36 locations in 6 mines in New Mexico and Colorado. Data on radon and radon daughter concentrations were obtained in only six mines, which were considered to be representative of uranium mines in the industry. The fractions of free atoms were not measured in this study.

Raghavayya and Jones (*4*) recently surveyed five mines in New Mexico and six in Colorado specifically to measure daughter equilibrium ratios and fractions of free atoms. A modified Tsivoglou method was used to calculate equilibrium ratios and a wire screen procedure was used to estimate the fractions of each individual daughter.

Equilibrium ratios

In both of the studies referred to, the radon daughter equilibrium ratios were found to vary over wide ranges. The highest ratios were almost 1:1:1 while the lowest were 1:0.21:0.03. The median ratios in the mines surveyed by Raghavayya and Jones were 1:0.56:0.42. The ratio between radon and RaA also varied widely particularly in the surveys by Raghavayya and Jones. As stated above, the AEC data were composed of mean daily averages at each station, while the NIOSH data are composed of individual samples at each station which may account for some of the wider distribution of ratios found in the latter work. Daughter equilibrium ratios are affected by such factors as rate of air change in the area, rate of radon emission into the area from broken rock or host rock, contamination of ventilation air from many sources, and plating out of radon daughters on surfaces. Thus, it is impossible to predict equilibrium ratios from ventilation measurements only.

Unattached atoms

The question of the fraction of each daughter present in the atmosphere as "unattached" atoms is important. It has been considered that in usual mine situations only small fractions of the RaB and RaC atoms will be present in this form, consequently, these fractions have been ignored in lung dose calculations. Measurements of unattached atoms are not easy, primarily because (as was pointed out by Breslin) there is no sharp distinction between unattached and attached atoms, but rather a spectrum of particle sizes. Therefore, the fractions of unattached atoms found are, in some degree, dependent on the method of measurement. The data reported by Raghavayya and Jones are not necessarily precise, but they do serve to give relative evaluations of fractions of unattached atoms of each daughter which may exist in actual mine situations.

The significant findings of these workers was that, contrary to prior theory, appreciable fractions of RaB and RaC do occur in mine atmospheres. The fractions of free daughter atoms ranged from RaA, 32.7 percent; RaB, 25.6 percent; RaC, 16.9 percent to RaA, 1.8 percent; RaB, 4.8 percent; RaC, 3.5 percent with a median value of RaA, 4.6 percent; RaB, 6.5 percent; RaC, 4.4 percent. Factors which affect the attachment of radon daughter atoms to particles include numbers of radioactive atoms per cm^3, number of particles per cm^3, number of negative ions per cm^3 available for neutralizing daughter ions, and recoil detachment of daughter atoms from particles. A laboratory study by McLaughlin (*5*) also found that unexpectedly large fractions of RaB and RaC existed as unattached atoms.

Discussion

In studies of the effect of variations in equilibrium ratios and fractions of free atoms on lung radiation doses, hypothetical conditions have been used because of the paucity of information on actual situations. The findings of the NIOSH surveys can be employed to give further insight into this question. For these calculations, the following assumptions were made.

1. In all cases, the radon daughter concentration was 1 WL.
2. All the daughter activity existed as unattached atoms or was attached to particles 0.2 μm in diameter.
3. Nose breathing removed 50 percent of the unattached atoms and 10 percent of those on particles. Mouth breathing removed approximately 10 percent of the unattached atoms and none of the particles.
4. The regional depositions were calculated in accordance with the procedure described by Altshuler et al. (*6*).

The numbers of daughter atoms of each species deposited in several regions of the respiratory tract were calculated using several combinations of equilibrium ratios and fractions of unattached atoms. The available alpha energy from radioactive decay deposited in each region was also calculated and the total value is given below each table.

Table 1. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 1 WL
Equilibrium ratio; RaA:RaB:RaC = 1:0.56:0.42 (median of ratios found)
Percent unattached atoms; RaA = 32.7, RaB = 25.6, RaC = 16.9
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	15	0	60	0	22	0
Main bronchi	30	0	118	0	43	0
Lobar	56	0	216	0	79	0
Segmental	72	11	279	60	102	37
Subsegmental	72	44	279	240	102	147

Total available alpha energy deposited = 17,638 MeV.

Table 1 shows the results using the median equilibrium ratio and the highest values for unattached atoms, while table 2 displays the calculations using the median ratio and the lowest values for free atoms. The high fractions of free atoms result in deposition of about 2.5 times the amount of potential alpha energy per liter per working level as do the low values.

Table 2. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 1 WL
Equilibrium ratio; RaA:RaB:RaC = 1:0.56:0.42 (median of ratios found)
Percent unattached atoms: RaA = 1.8, RaB = 4.8, RaC = 3.5
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	1	0	11	0	0	0
Main bronchi	2	0	22	0	9	0
Lobar	3	0	41	0	16	0
Segmental	4	16	52	77	21	43
Subsegmental	4	64	52	307	21	171

Total available alpha energy deposited = 7,715 MeV.

Tables 3 and 4 display similar data using the median values for fractions of unattached atoms with the highest and lowest equilibrium ratios found, respectively. These calculations

Table 3. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 1 WL
Equilibrium ratio; RaA:RaB:RaC = 1:0.21:0.03 (lowest ratios found)
Percent unattached atoms; RaA = 4.6, RaB = 6.5, RaC = 4.4 (median values)
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	5	0	14	0	1	0
Main bronchi	11	0	28	0	2	0
Lobar	19	0	51	0	3	0
Segmental	25	38	65	69	5	7
Subsegmental	25	154	65	309	5	29

Total available alpha energy deposited = 8,730 MeV.

show that wide variations in equilibrium ratios influence the potential alpha energy deposited per liter per working level only slightly.

Table 4. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 1 WL
Equilibrium ratio; RaA:RaB:RaC = 1:1.0:0.98 (highest ratios found)
Percent unattached atoms: RaA = 4.6, RaB = 6.5, RaC = 4.4 (median values)
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	1	0	15	0	7	0
Main bronchi	2	0	30	0	15	0
Lobar	4	0	55	0	27	0
Segmental	6	9	70	75	34	55
Subsegmental	6	35	70	299	34	221

Total available alpha energy deposited = 8,510 MeV.

Table 5. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 1 WL
Equilibrium ratio; RaA:RaB:RaC = 1:0.47:0.25 (actual ratios found)
Percent unattached atoms; RaA = 32.7, RaB = 25.6, RaC = 16.9
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	19	0	62	0	16	0
Main bronchi	38	0	124	0	32	0
Lobar	70	0	227	0	58	0
Segmental	91	14	293	70	76	30
Subsegmental	91	55	293	279	76	122

Total available alpha energy deposited = 18,500 MeV.

Table 5 uses the highest fractions of unattached atoms found with the equilibrium ratio that existed at that station, while table 6 uses the lowest fractions of unattached atoms with the corresponding ratios. The particle counts at each station also are given. The total energy deposited in each case is very similar to those found in tables 1 and 2, respectively.

Table 6. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 1 WL
Equilibrium ratio; RaA:RaB:RaC = 1:0.61:0.56 (actual ratios found)
Percent unattached atoms; RaA = 1.8, RaB = 4.8, RaC = 3.5
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	1	0	11	0	5	0
Main bronchi	1	0	21	0	10	0
Lobar	3	0	39	0	19	0
Segmental	4	14	50	73	25	50
Subsegmental	4	56	50	292	25	200

Total available alpha energy deposited = 7,741 MeV.

These calculations show that the primary factors influencing the amount of potential alpha energy deposited in the respiratory tract per WL are the fractions of unattached atoms. This deposited activity is subject to removal from the lung by clearance mechanisms such as mucus flow or direct passage from the lung to the blood.

The data obtained in the NIOSH mine surveys can also be used to estimate the influence of varying radon to daughter ratios on MeV of available alpha energy deposited. This question is important when atmospheric concentrations of radon are employed as the measure of relative biological hazard. Tables 7 and 8 illustrate this effect in two actual situations, one with a relatively high equilibrium ratio and the other with a relatively low ratio. The fractions of free atoms were those actually found, and the data were normalized to a radon concentration of 100 pCi/liter. These tables show that varying equilibrium ratios have a marked effect on the MeV of available alpha energy deposited per liter per pCi of radon. In these cases, the available alpha energy deposited varies by a factor of almost 6.

The calculations described above have shown that there is an appreciable effect on the potential alpha energy deposited in the lungs, caused by a change in the unattached fraction of radon

Table 7. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 100 pCi/liter
Equilibrium ratio; Rn:RaA:RaB:RaC = 1:0.84:0.83:0.81
Percent unattached atoms; RaA = 4.0, RaB = 5.6, RaC = 3.5
Radon concentration = 100 pCi/liter
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	1	0	10	0	5	0
Main bronchi	2	0	21	0	9	0
Lobar	3	0	38	0	17	0
Segmental	4	7	49	61	22	45
Subsegmental	4	28	49	270	22	178

Total available alpha energy deposited = 6,716 MeV.

Table 8. Regional deposition of radon daughter atoms per liter of air inhaled

Conditions: Atmospheric concentration of radon daughters = 100 pCi/liter
Equilibrium ratio; Rn:RaA:RaB:RaC = 1:0.36:0.13:0.08
Percent attached atoms; RaA = 3.9, RaB = 6.2, RaC = 6.1
Radon concentration = 100 pCi/liter
Nose breathing

Region of respiratory tract	Atoms of RaA deposited		Atoms of RaB deposited		Atoms of RaC deposited	
	Unattached	Attached	Unattached	Attached	Unattached	Attached
Trachea	0	0	2	0	1	0
Main bronchi	1	0	4	0	2	0
Lobar	1	0	7	0	3	0
Segmental	2	3	9	9	4	4
Subsegmental	2	12	9	38	4	10

Total available alpha energy deposited = 1,137 MeV.

daughters. If radon concentration is used to determine potential exposure, radon to daughter ratios also have a marked effect on potential alpha energy deposition. The extremes determined in these calculations are based on conditions found in actual working mines. The data contained in the tables will allow lung doses to be calculated, using actual rather than theoretical conditions.

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Radiological Survey of New London Harbor, Thames River, Conn., and Environs

Sam T. Windham[1] *and Charles R. Phillips*[2]

In July 1972, the Eastern Environmental Radiation Facility, in cooperation with the U.S. Naval Ship Systems Command, conducted a radiological survey of the New London Harbor, Thames River and environs to determine if nuclear ship activity in that area has contributed radioactivity which could result in detectable radiation exposure to the public. Comparison with a similar survey conducted in 1966 show that cobalt-60 activity levels in sediment have decreased by an average factor of 33 due to a reduction in the amount of radioactivity discharged, radioactive decay and natural sedimentation. Analysis of samples indicative of direct pathways for human exposure lead to the conclusion that no significant radiation exposure to the public has resulted from nuclear ship operations in this area. It is concluded that the environmental surveillance routinely conducted by the Navy should be adequate to assure protection of the public from the routine nuclear ship operations.

The Eastern Environmental Radiation Facility[3] (EERF) of the U.S. Environmental Protection Agency in cooperation with the U.S. Naval Ship Systems Command (NAVSHIPS) has conducted radiological surveillance programs in a number of ports which serve nuclear-powered vessels. These studies were begun in 1963 and were conducted at ports on the East, West, and Gulf Coasts of the United States and in Pearl Harbor, Hawaii. These surveys were undertaken to determine if nuclear-powered vessel operations, including berthing, repair and servicing, had resulted in environmental radioactivity levels which could contribute a detectable radiation exposure to the public. The survey of the harbor at Groton-New London, Conn., in July 1972 was a followup of a previous survey at this port conducted in 1966 (*1*).

Consideration in design of the survey

A primary consideration in the protocol for the survey was to be able to make a comparison between the radioactivity levels present in the harbor environs in 1972 and those present in 1966. Sampling procedures and locations were selected so that direct comparisons could be made with the data obtained in the 1966 survey wherever practical. Locations of vessels and additions and changes in the docks prevented resurveying of some of the locations used in 1966.

Previously published data (*2*) show that the quantity of radioactivity discharged annually into the Groton-New London Harbor was reduced by a factor of 10 between 1967 and 1971. The total quantity of radioactivity discharged to the harbor by Electric Boat Division, the U.S. Submarine Base, and the submarine tender at State Pier in calendar year 1971 was less than 0.001 curie, excluding tritium.

Characteristics of the Thames River and environs

The Thames River is a tidal estuary arising at the confluence of the Yantic and Shetucket Rivers approximately 24 km (15 miles) north of the Groton-New London harbor area. The river varies in width from 0.21 km (0.13 miles)

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[3] Formerly the Southeastern Radiological Health Laboratory, U.S. Public Health Service.

to a maximum of 1.82 km (1.13 miles) where it empties into Long Island Sound. The mean tidal range of the river at New London is 76 cm (2.5 feet).

The bottom sediment is characterized mainly by mud, gravel, and sand. Because of silting, maintenance dredging is required in the channel and in the areas adjacent to the piers. Between the 1966 and 1972 surveys, dredging had been done in an area adjacent to pier 17 and the marine railway at the submarine base and in the area north of the State pier. The material removed in the dredging operation is transported by barge to a dumping area at sea.

Personal communications with local authorities indicated no commercial fishing is done in the Groton-New London Harbor area, although sport fishing and power and sail boating are popular. There appeared to be no swimming in the harbor area with the public swimming areas located on Long Island Sound.

Both Groton and New London obtain their city water supplies from reservoirs fed by surface streams. The harbor area is industrialized with essentially no agriculture along the shore. The major industries in the harbor area are the U.S. Submarine Base, General Dynamics Electric Boat Division, and Charles Pfizer and Sons.

Survey and analytical methods

An underwater scintillation probe containing a 10 by 10 cm NaI(Tl) detector was used in conjunction with a multichannel pulse height analyzer to obtain gamma spectra of the harbor bottom sediment.

Probe measurements were made by lowering the detector to the harbor bottom and counting for 10 minutes. A background spectrum was taken at the same location as in the 1966 survey and automatically was subtracted from subsequent spectra. This area (location 1) is located at "light 14" just above Dow Chemical Company and should be unaffected by nuclear ship operations downstream (figure 1). Data were printed out on a parallel printer.

The probe was used as a semiquantitative tool in conjunction with bottom sediment samples on which quantitative radionuclide analyses were performed in the laboratory. Data obtained using the probe were useful in delineating general areas of radioactivity whereas the laboratory analysis of sedment samples taken within these areas provided quantitative results.

A standard Petersen dredge was used to sample approximately the top 10 cm of sediment. The samples were prepared for analysis by drying at 110°C and grinding to a fine powder. The samples were gamma counted in a 1-liter Marinelli beaker on a 10 by 10 cm NaI (Tl) detector using a multichannel analyzer.

Vegetation samples (*Fucus*, an intertidal rockweed) were collected as available in the harbor area. The samples collected were generally found growing on rocks and pier pilings. The vegetation samples were dried at 110°C, ground to a fine powder, and counted in a "cot-

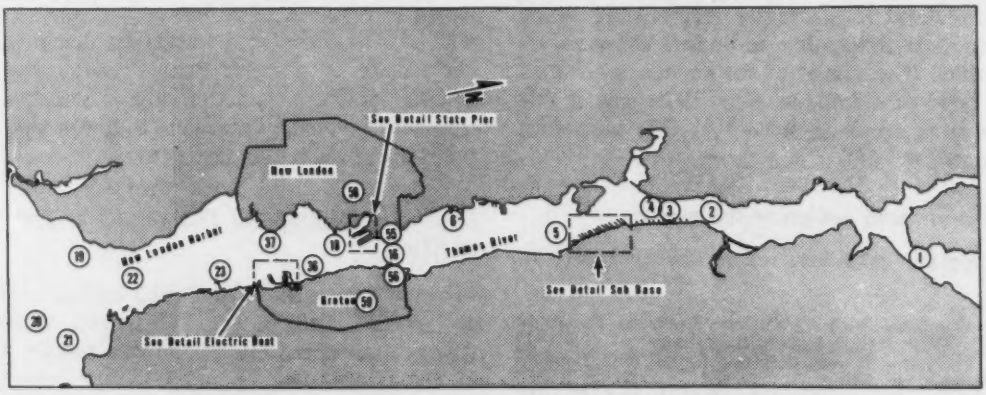

Figure 1. Thames river, New London harbor sampling locations

tage cheese container" on a 10 by 10 cm NaI (Tl) detector.

Fish samples were caught in the harbor area and lobsters were purchased from a local distributor. The lobsters were trapped in the Long Island Sound area and represented the source of commercial lobsters caught nearest to the Groton-New London area. In the laboratory, these samples were chopped individually to an even consistency and counted wet in a 1-liter Marinelli beaker on a 10 by 10 cm NaI (Tl) detector.

Harbor water and drinking water from the Groton and New London municipal supplies were collected. Analysis consisted of a direct gamma spectrum analysis of 3.5 liters in a Marinelli beaker plus a gamma analysis (well crystal of a 40-ml concentrate from an evaporated 4-liter sample.

Core samples of the harbor bottom were collected by divers at several locations. These samples were used to define the vertical distribution of radioactivity in the harbor bottom. The samples were collected by pushing a 2.5 cm diameter by 61-cm long plastic tube into the sediment as far as possible and then capping the ends of the tube. In the laboratory, the cores were cut into 2.5 cm segments and counted in a 10 by 10 cm NaI (Tl) well crystal.

Results and discussion

Figures 1–8 show the sampling locations for the 1972 survey and the cobalt-60 concentration as indicated by the analysis of sediment samples from these locations (table 1). Previous surveys have shown cobalt-60 to be the predominant radioisotope introduced into the environment as a result of nuclear operation (*1*). For comparison, the cobalt-60 activities found in the 1966 and 1972 surveys are given in table 2 for all common sampling locations. At these common sampling locations it is seen that the cobalt-60 levels are lower by an average factor of 33 in the 1972 survey as compared to the 1966 survey. This reduction is due largely to the effects of reducing the quantity of radioactivity discharged to the harbor, the effects of natural sedimentation in the estuary,[4] and loss by radioactive decay. Measurements made using the underwater gamma probe substantiated this reduction in activity based on the spectra obtained on the two surveys.

Conversations with local residents and seafood suppliers indicated that there is no commercial fishing in the harbor area; therefore, fish samples were difficult to obtain. Flounder and a species of nonedible fish which were analyzed showed no detectable amounts of cobalt-60. Other than natural activity and a trace of zirconium-niobium-95 attributed to fallout in

[4] Natural sedimentation could cause a reduction in cobalt-60 concentrations by diluting contaminated sediment with uncontaminated sediment and by covering the contaminated sediment.

Table 1. Results of silt analysis, Groton, Conn. harbor survey, July 1972

Sample ID	Cobalt-60 [a] activity (pCi/g dry weight)	Sample ID	Cobalt-60 [a] activity (pCi/g dry weight)	Sample ID	Cobalt-60 [a] activity (pCi/g dry weight)
GS-1	1.1± 4%	GS-17	6.6± 2%	GS-33	9.3± 1%
GS-2	.4± 6%	GS-18	2.0± 3%	GS-34	10.3± 1%
GS-3	.9± 4%	GS-19	1.0± 4%	GS-52	1.4± 4%
GS-5	.8± 5%	GS-22	.4± 7%	GS-55	1.8±11%
GS-7	2.4± 2%	GS-24		GS-56	.2± 8%
GS-8	4.0± 2%	GS-25	1.1± 4%	GS-38	1.3± 4%
GS-12	5.5± 2%	GS-26	2.3± 3%	GS-41	1.4± 3%
GS-13	1.7± 3%	GS-28	1.4± 3%	GS-43	1.3± 3%
GS-14	3.2± 2%	GS-29	1.5± 3%	GS-45	1.5± 3%
GS-16-A	.9± 5%	GS-30	2.5± 3%	GS-46	1.5± 3%
GS-16-B	.9± 5%	GS-31	2.5± 3%	GS-48	1.9± 3%
GS-16-C	.8± 6%	GS-32	26.1± 1%	GS-51	1.0± 4%

[a] Analysis of samples for potassium-40, zinc-65, zirconium-niobium-95, ruthenium-106, cesium-137, cerium-144, bismuth-214, and thorium-232 indicated levels of activity which were consistent with natural background and fallout from weapons testing.
The error expressed is the percentage of the 2-sigma counting error for a normal distribution.

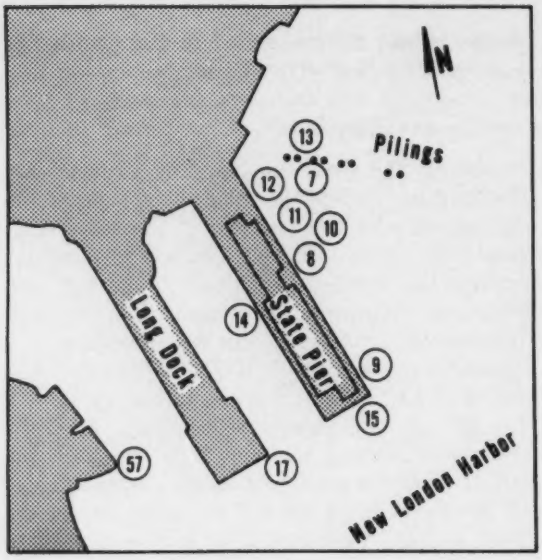

Figure 2. State pier detail—sampling locations

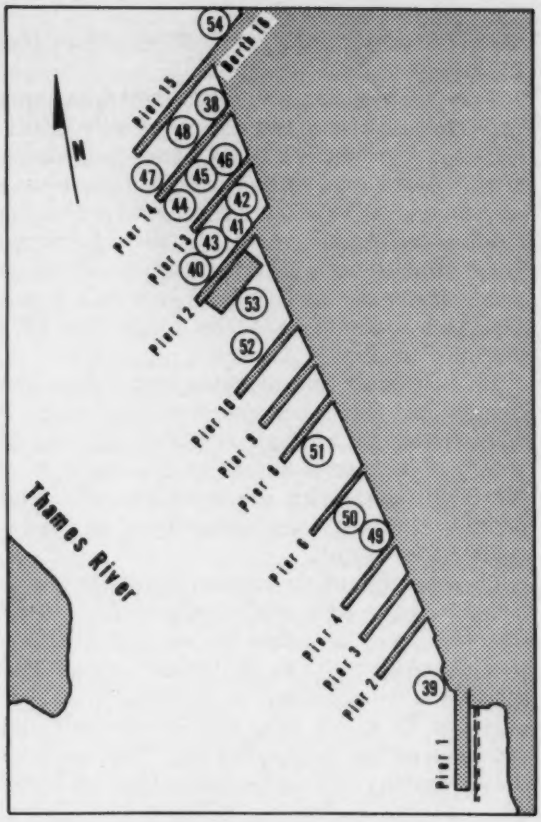

Figure 3. Submarine base detail—sampling locations

one lobster sample, no radioactivity was found in any of these samples. Data from analysis of these samples are in table 3.

Fucus, an intertidal rockweed, was the only readily available vegetation in the harbor area. The locations and results of the gamma analysis of these samples are detailed in table 4. From the data it is seen that trace amounts of cobalt-60 were present in samples collected near the State Pier and Long Dock. Other than the cobalt-60, the samples contained only varying amounts of natural background and fallout activity.

Table 2. Comparison of cobalt-60 activity in sediment samples collected in 1966 and 1972

1972 location	Cobalt-60 activity (pCi/g dry weight)		Reduction factor *	1972 location	Cobalt-60 activity (pCi/g dry weight)		Reduction factor *	1972 location	Cobalt-60 activity (pCi/g dry weight)		Reduction factor *	1972 location	Cobalt-60 activity (pCi/g dry weight)		Reduction factor *
	1966	1972			1966	1972			1966	1972			1966	1972	
1	1.0	1.1		15	NS	NS		29	NS	1.5		43	21.0	1.3	16.2
2	NS	.4		16	32.0	0.9		30	362	2.5	144.8	44	30.4	NS	
3	NS	.9		17	NS	6.6		31	20.3	2.5	8.12	45	NS	1.5	
4	4.8	NS		18	NS	2.0		32	NS	26.1		46	14.4	1.5	9.6
5	NS	.8		19	NS	1.0		33	NS	9.3		47	13.6	NS	
6	NS	NS		20	NS	NS		34	NS	10.3		48	23.1	1.9	12.2
7	NS	2.4		21	NS	NS		35	NS	NS		49	NS	NS	
8	200	4.0	50	22	NS	.4		36	NS	NS		50	NS	NS	
9	NS	NS		23	18.4	NS		37	30.3	NS		51	16.5	1.0	16.5
10	NS	NS		24	NS	1.4		38	NS	1.3		52	16.4	1.4	11.7
11	NS	NS		25	NS	1.1		39	NS	NS		53	NS	NS	
12	NS	5.5		26	NS	2.3		40	6.2	NS		54	NS	NS	
13	NS	1.7		27	NS	NS		41	14.9	1.4	10.6	55	NS	1.8	
14	117	3.2	36.6	28	69.2	1.4	49.4	42	NS	NS		56	NS	.2	

* Reduction factor = $\frac{\text{Cobalt-60 activity—1966 survey}}{\text{Cobalt-60 activity—1972 survey}}$

NS, no sample from this location.

Table 3. Results of fish analysis, Groton, Conn. harbor survey, July 1972

Identification	Specific gamma activity (pCi/kg wet weight)	
Lobster	^{40}K	1,658 ± 13%
Lobster	^{95}Zr-Nb	43 ± 33%
	^{40}K	1,352 ± 16%
Bottom feeders	^{40}K	2,720 ± 7%
Flounder	^{40}K	2,567 ± 7%

Table 4. Results of vegetation analysis, Groton, Conn. harbor survey, July 1972

Sample identification	Specific gamma activity (pCi/kg dry weight)	
GV-36 (from piling at Electric Boat)	^{137}Cs	212 ± 37%
	^{95}Zr-Nb	848 ± 9%
	^{232}Th	194 ± 87%
	^{40}K	30,318 ± 4%
GV-17 (from location 57)	^{106}Ru	461 ± 69%
	^{137}Cs	77 ± 97%
	^{95}Zr-Nb	624 ± 13%
	^{232}Th	173 ± 72%
	^{60}Co	169 ± 43%
	^{40}K	24,041 ± 4%
GV-57 (from piling of State Pier)	^{106}Ru	844 ± 41%
	^{95}Zr-Nb	755 ± 10%
	^{232}Th	213 ± 63%
	^{60}Co	336 ± 24%
	^{40}K	24,855 ± 4%
GV-54 (from piling on Pier 16 in Sub Base)	^{144}Ce	3,891 ± 10%
	^{106}Ru	12,887 ± 0.6%
	^{95}Zr-Nb	7,071 ± 1%
	^{40}K	8,410 ± 15%

Water samples collected in the harbor area and from the Groton and New London municipal water supplies showed no activity other than natural potassium-40 which was detectable in the harbor water samples. Data from analysis of water samples are in table 5.

Table 5. Results of water analysis, Groton, Conn. harbor survey, July 1972

Location[a]	Gamma scan 3.5 liter geometry (pCi/liter)		Gamma scan 4 liters evaporated to 40 ml geometry (pCi/liter)[b]	
GW-1 Location 1	^{40}K	64 ± 56%	^{40}K	58 ± 50%
GW-2 Location 2	^{40}K	99 ± 37%	^{40}K	76 ± 23%
GW-58 New London Municipal Supply		ND		ND
GW-59 Groton Municipal Supply		ND		ND
GW-11 Location 11	^{40}K	173 ± 22%	^{40}K	134 ± 20%
GW-40 Location 40	^{40}K	193 ± 20%	^{40}K	110 ± 25%

[a] See figures 1–4 for location details.
[b] The error expressed is the percentage of the 2-sigma counting error for a normal distribution.
ND, nondetectable.

Core samples were taken at 10 locations to determine the vertical distribution of radioactivity in the sediment. Data from the analysis of these samples were presented in table 6.

The results of core samples taken from the State Pier area, the Submarine Base, and at Electric Boat near piers C and D show that the principal cobalt-60 radioactivity is to be found at a depth of 15 to 20 cm in the sediment. Most of the activity in the top few centimeters in these areas is due to natural potassium-40 and thorium as well as typical fallout radionuclides.

The results of analyses of core samples from locations 31 and 34 in the South Yard at Electric Boat show that the majority of cobalt-60 radioactivity was in the upper 13 cm of sedi-

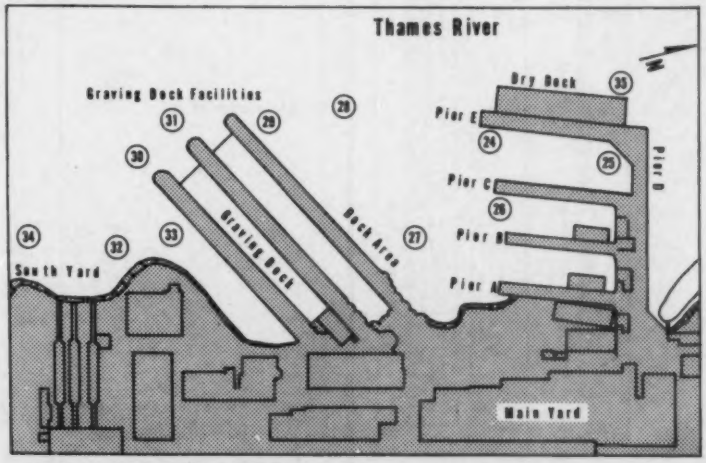

Figure 4. Electric boat detail—sampling locations

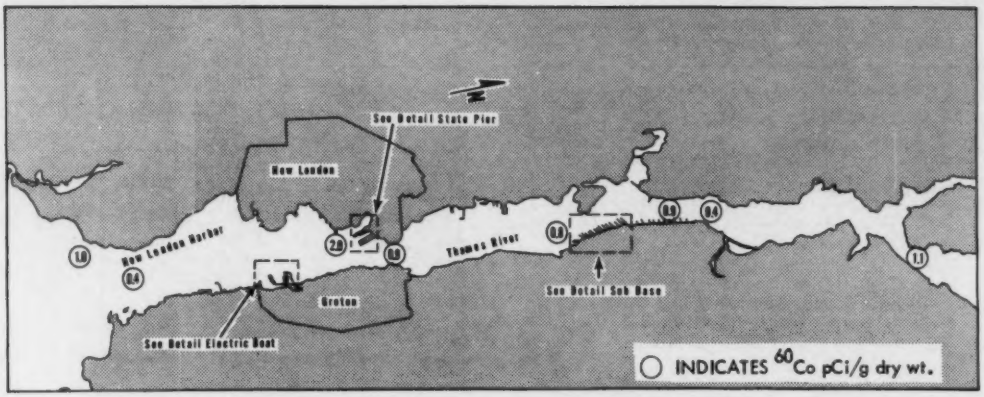

Figure 5. Thames river, New London harbor and data

Table 6. Results of core samples, [a] Groton, Conn. harbor survey, July 1972

Sample identification [b]	Depth below sediment-water interface (cm)	Cobalt-60 (pCi/g dry)
GC-8, location 8	2.5	[c] 9.3±10%
	5.1	2.5±24%
	7.6	2.4±18%
	10	3.2±19%
	13	5.9±12%
	15	5.1±13%
	18	25.1± 5%
	20	297.3± 1%
GC-12, location 12	2.5	ND
	5.1	.8±85%
	7.6	2.2±27%
	10	1.6±32%
	13	1.5±28%
	15	17.1± 5%
	18	4.3±14%
	20	7.7±10%
	23	50.5± 3%
	25	254.6± 2%
GC-14, location 14	2.5	3.2±38%
	5.1	8.0±10%
	7.6	1.4±48%
	10	3.3±21%
	13	2.7±22%
	15	1.0±30%
	18	2.6±23%
	20	2.2±25%
	23	4.7±15%
	25	7.6±10%
	28	10.8± 7%
	30	.7±68%
	33	1.3±44%
GC-25, location 25	2.5	1.0±57%
	5.1	1.3±42%
	7.6	.8±66%
	10	.7±73%
	13	2.8±19%
	15	13.4± 6%
	18	21.5± 4%
	20	28.8± 4%
	23	.6±53%
	25	5.0±10%
GC-26, location 26	2.5	ND
	5.1	1.1±61%
	7.6	2.2±29%
	10	1.2±42%
	13	6.4±11%
	15	27.1± 4%
	18	73.2± 2%
	20	7.3± 9%
	23	14.4± 6%
	25	36.9± 3%
GC-31, location 31	2.5	2.7±17%
	5.1	4.6±15%
	7.6	2.1±32%
	10	15.8± 6%
	13	36.9± 3%
	15	1.6±35%
GC-31, location 31	18	1.2±39%
	20	2.6±22%
	23	1.5±26%
	25	1.9±21%
	28	2.1±19%
	30	4.3±10%
	33	.8±43%
GC-34, location 34	2.5	6.3± 9%
	5.1	7.0± 9%
	7.6	2.2±35%
	10	.6±53%
	13	ND
	15	.5±76%
GC-43, location 43	2.5	ND
	5.1	ND
	7.6	.7±96%
	10	ND
	13	1.1±52%
	15	2.0±29%
	18	5.8±13%
	20	13.8± 6%
	23	3.9±19%
GC-45, location 45	2.5	ND
	5.1	ND
	7.6	1.2±73%
	10	ND
	13	.9±81%
	15	2.6±30%
	18	3.5±22%
	20	1.6±42%
	23	.5±76%
	25	1.7±40%
	28	3.2±22%
	30	2.3±28%
GC-48, location 48	2.5	ND
	5.1	ND
	7.6	ND
	10	ND
	13	2.2±55%
	15	ND
	18	ND
	20	3.2±39%
	23	ND
	25	.9±76%
	28	ND
	30	2.8±25%
	33	1.3±43%
	36	ND
	38	.5±83%
	41	2.8±19%
	43	.5±99%
	46	.9±66%

[a] Analysis of samples for potassium-40, zinc-65, zirconium-niobium-95, ruthenium-106, cesium-137, cerium-144, bismuth-214, and thorium-232 indicated levels of activity which were consistent with natural background and fallout from weapons testing.

[b] See figures 1–4 for location details.

[c] The error expressed is the percentage of the 2-sigma counting error for a normal distribution.

ND, nondetectable.

ment. This apparently is due to redistribution of the upper layers of sediment due to changing current in the South Yard.[5]

Table 7 shows a comparison of the cobalt-60 activity in the top 10 cm of the core samples with that from the dredge samples taken at the same locations. The dredge used to collect sediment samples also was sampling approximately the top 10 cm.

With three exceptions (locations 12, 31, and 34, table 7), the data agree quite well. At locations 31 and 34 (table 7), if it could be assumed that the dredge sampled only the top 5 cm instead of the top 10 cm, data from these locations would be in much better agreement. If little silting had taken place at these locations (as speculated previously), the absence of this soft material would cause the dredge to dig less deeply into a firm bottom and thus collect a shallow sample.

[5] Personal communication, Naval Ship Systems Command.

Table 7. Comparison of dredge samples with top 10 cm of core samples from same location

Location	Average cobalt-60 activity in core sample (pCi/g dry weight)		Cobalt-60 activity in dredge sample (pCi/g dry weight)
	Top 10 cm	Top 5 cm	
8	4.4		4.0
12	1.5		5.5
14	4.0		3.2
25	1.0		1.1
26	1.5		2.3
31	6.3	3.7	2.5
34	4.0	6.7	10.3
43	.7		1.3
45	1.2		1.5
48	2.2		1.9

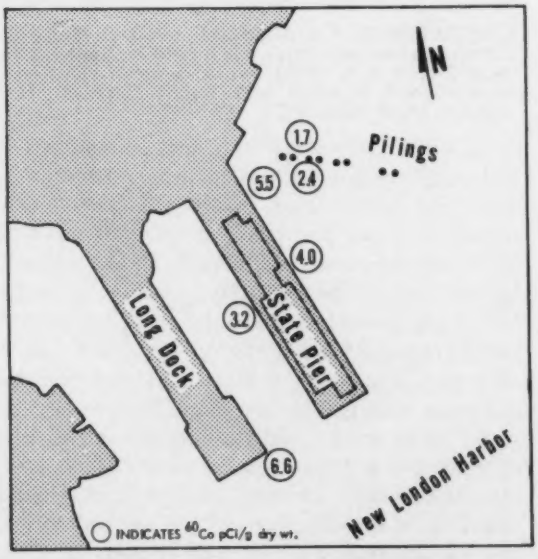

Figure 6. State pier detail and data

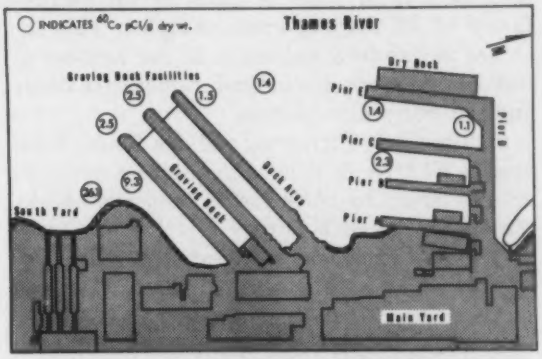

Figure 7. Electric Boat detail and data

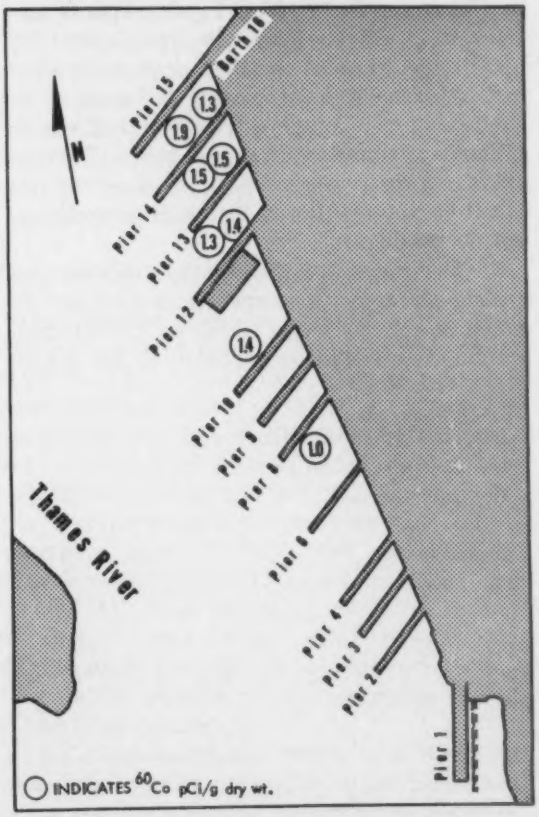

Figure 8. Submarine base detail and data

Conclusions

As a result of the 1972 survey the following conclusions could be drawn:

1. The data of this report show that cobalt-60 activity levels in Thames River sediments in the harbor at Groton-New London, Conn., have decreased from 1966 to 1972 by an average factor of 33 for the areas sampled. This decrease is due to a reduction in the amount of radioactive waste discharged, radioactive decay and natural sedimentation.

2. The State Pier area and the South Yard area at Electric Boat have the highest cobalt-60 activity levels found in the 1972 survey as was the case in the 1966 survey.

3. No evidence was found of cobalt-60 activity in areas where it was absent in the 1966 survey.

4. The routine environmental radiological monitoring program conducted by the NAVSHIPS in the Groton-New London area is adequate to effectively assess the radiological impact of nuclear ships and their support facilities in that area. This conclusion is based on an analysis of the sampling frequency and the locations and number of samples taken. Further, data from their recent report (*2*) show that the cobalt-60 activity levels in the river sediment are decreasing.

5. The results of this survey indicate that nuclear-powered vessel operations have not resulted in activity levels which could contribute a significant radiation exposure to the public. This conclusion is based on the fact that:

   a. activity is located principally in harbor sediment and not in fish or lobster,
   b. levels of radioactivity are quite low compared to the Atomic Energy Commission standards,
   c. there is no commercial fishing in the harbor, and
   d. no activity other than natural radioactivity was found in the harbor and drinking water.

The continuation of current waste discharge practices and the Navy routine monitoring program should be sufficient to assure continued absence of significant public exposure for routine nuclear ship operations.

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(*2*) MILES, M. E., G. L. SJOBLOM, and R. D. BURKE. Environmental monitoring and disposal of radioactive wastes from U.S. Naval nuclear-powered ships and their support facilities, 1971. Radiat Data Rep 13: 469–478 (September 1972).

SECTION I. MILK AND FOOD

Milk Surveillance, July 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption readily can be obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 65 sampling stations: 63 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 16 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—7 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare—16 sampling stations

The sampling locations that make up the networks reporting presently in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

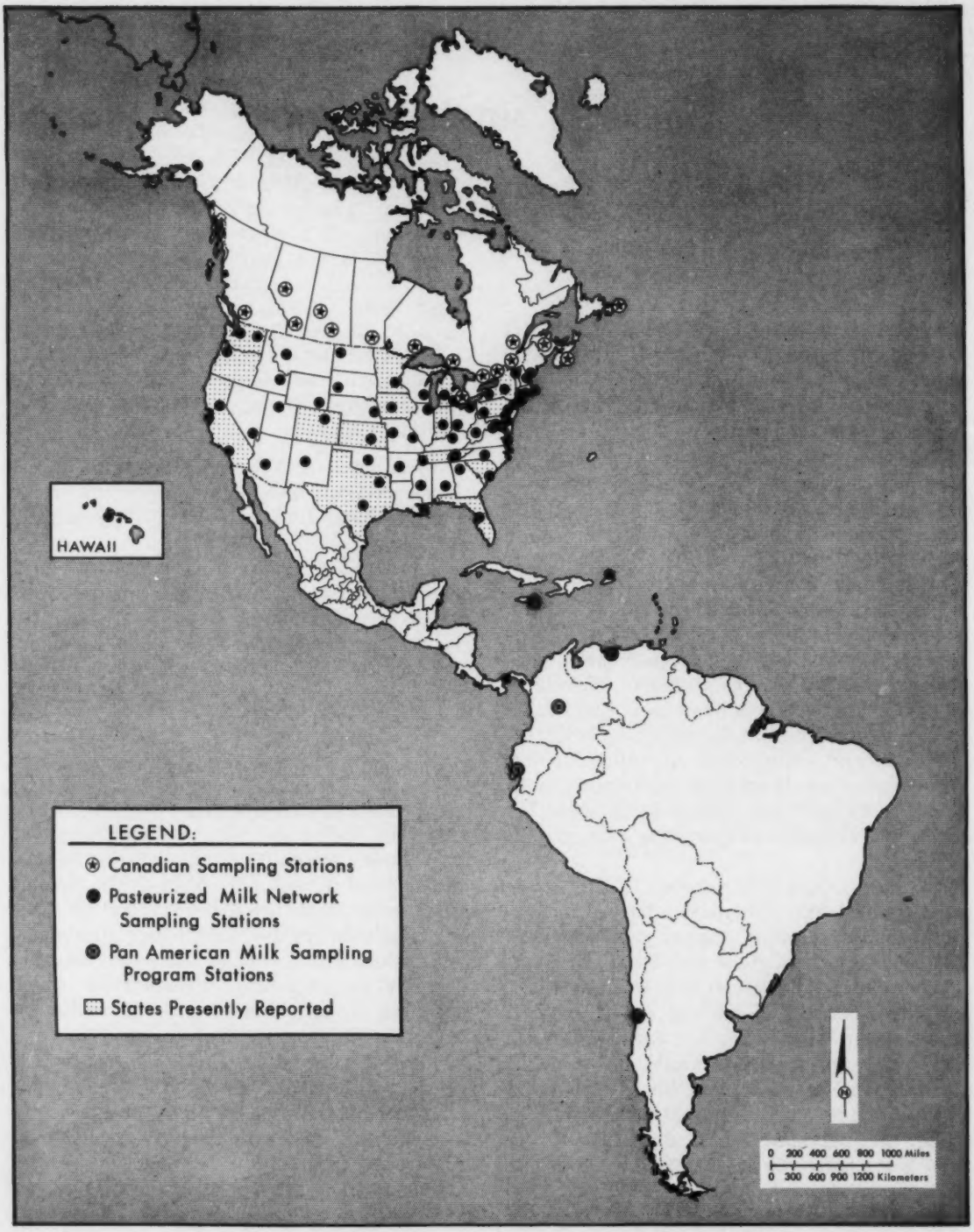

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, first it was necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been previously outlined (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels,

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131 (96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137 (53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89 (29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90 (32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and generally is increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sampling determinations. The treatment of measurements equal to or below those practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range also has been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the United States data on radioactivity in milk in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are reported routinely in *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the

Table 2. Concentrations of radionuclides in milk for July 1973 and 12-month period August 1972 through July 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	3	5	12 (2)	5
Alaska:	Palmer [c]	P	3	4	12	1
Ariz:	Phoenix [c]	P	0	0	0	0
Ark:	Little Rock [c]	P	12	10	0	2
Calif:	Los Angeles [c]	P	0	0	0	0
	Sacramento [c]	P	0	1	0	0
	San Francisco [c]	P	0	0	0	0
	Del Norte	P	10	11	0	6
	Fresno	P	0	1	0	2
	Humboldt	P	0	3	0	1
	Los Angeles	P	0	1	0	1
	Mendocino	P	2	2	0	3
	Sacramento	P	0	2	0	3
	San Diego	P	0	1	0	3
	Santa Clara	P	2	2	0	2
	Shasta	P	2	2	0	4
	Sonoma	P	0	2	0	2
Colo:	Denver [c]	P	NA	2	0	0
	East	R	NS	NA	NS	14
	Northeast	R	NA	NA	[d]0 (2)	1
	Northwest	R	NS	NA	NS	2
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NA	NA	[d]0	2
	West	R	NA	NA	[d]0	0
Conn:	Hartford [c]	P	4	4	0	4
	Central	P				
Del:	Wilmington [c]	P	8	6	0	5
D.C:	Washington [c]	P	4	4	0	2
Fla:	Tampa [c]	P	4	4	34	30
	Central	R	5	5	28	33
	North	R	4	6	10	13
	Northeast	R	NA	6	25	31
	Southeast	R	4	5	41	45
	Tampa Bay area	P	3	5	31	31
	West	R	7	8	14	8
Ga:	Atlanta [c]	P	4	6	9 (3)	7
Hawaii:	Honolulu [c]	P	0	1	0	0
Idaho:	Idaho Falls [c]	P	3	3	0	0
Ill:	Chicago [c]	P	5	5	0	2
Ind:	Indianapolis [c]	P	5	5	7 (2)	3
	Central	P	7	7	0	3
	Northeast	P	6	5	10	3
	Northwest	P	10	8	0	9
	Southeast	P	9	7	0	5
	Southwest	P	10	7	10	9
Iowa:	Des Moines [c]	P	4	5	0 (3)	0
	Des Moines	P	5	6	0	0
	Iowa City	P	5 (3)	5	0 (3)	0
	LeMars	P	4	4	0	2
	Little Cedar	P	7	7	0	2
Kans:	Wichita [c]	P	6	5	0	0
	Coffeyville	P	8	8	3	3
	Dodge City	P	5	4	8	5
	Falls City, Nebr	R	5	3	6	7
	Hays	P	7	9	1	6
	Kansas City	P	5	8	5	8
	Topeka	P	6	7	7	4
	Wichita	P	6	8	5	10
Ky:	Louisville [c]	P	5	5	0	1
La:	New Orleans [c]	P	8	9	7 (2)	1
Maine:	Portland [c]	P	8	6	20	19
Md:	Baltimore [c]	P	8	6	12	6
Mass:	Boston [c]	P	8	7	25	16
Mich:	Detroit [c]	P	6	6	0	3
	Grand Rapids [c]	P	7	8	0	1
	Bay City	P	9	7	0	0
	Charlevoix	P	3	6	3 (4)	3
	Detroit	P	0	4	0	1
	Grand Rapids	P	7	5	0	1
	Lansing	P	11	6	8 (2)	4
	Marquette	P	18 (2)	7	16 (2)	10
	Monroe	P	17	6	0 (2)	0
	South Haven	P	5	7	8 (5)	4
Minn:	Minneapolis [c]	P	7	7	0 (2)	6
	Bemidji	P	7	7	0	13
	Duluth	P	18	15	20	21
	Fergus Falls	P	4	7	0	0
	Little Falls	P	26	24	67	28
	Mankato	P	4	5	0	0
	Marshall	P	4	4	0	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for July 1973 and 12-month period August 1972 through July 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
Minn:	Minneapolis	P	10	9	0	11
	Rochester	P	6	8	0	0
Miss:	Jackson *	P	8	8	16	7
Mo:	Kansas City *	P	4	4	0	0
	St. Louis *	P	8	6	11	1
Mont:	Helena *	P	0	2	0	0
Nebr:	Omaha *	P	0	3	0	0
Nev:	Las Vegas *	P	8	3	0	0
N.H:	Manchester *	P	9	7	15	12
N.J:	Trenton *	P	4	6	0	6
N. Mex:	Albuquerque *	P	0	0	0	0
N.Y:	Buffalo *	P	6	4	0	3
	New York City *	P	4	6	12	5
	Syracuse *	P	6	6	11	2
	Albany	P	5 (5)	4	0 (5)	0
	Buffalo	P	5	4	0	0
	Massena	P	12	6	25	0
	New York City	P	15	7	0	0
	Syracuse	P	4	5	0	0
N. C:	Charlotte *	P	9	7	13	7
N. Dak:	Minot *	P	6	7	6 (2)	0
Ohio:	Cincinnati *	P	6	5	0 (2)	2
	Cleveland *	P	7	6	8 (3)	3
Okla:	Oklahoma City *	P	2	3	0	0
Oreg:	Portland *	P	0	4	16 (2)	1
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	R	NA		NA	
Pa:	Philadelphia *	P	5	5	0 (3)	2
	Pittsburgh *	P	10	8	7 (2)	5
	Dauphin	P	6	5	0	2
	Erie	P	8	7	4	3
	Philadelphia	P	6	4	0	3
	Pittsburgh	P	6	6	0	2
R. I:	Providence *	P	4	5	13	3
S. C:	Charleston *	P	5	7	19	9
	Chapin	R	NS	8	NS	11
	Clemson	R	9	7	21	6
	Columbia	R	NS	7	NS	10
	Fairfield	R	NS	7	NS	13
	Hartsville-02	R	7	6	8	12
	Hartsville-03	R	16	17	14	16
	Lee County	R	8	8	14	17
	Oconee County	R	NS	8	NS	7
	Pickens	R	9	7	10	5
	Williston	R	NS	7	NS	15
	Winnsboro	R	NS	8	NS	24
S. Dak:	Rapid City *	P	8	5	13	1
Tenn:	Chattanooga *	P	6	6	0	5
	Knoxville *	P	NS		NS	
	Memphis *	P	6	6	0	2
	Chattanooga	P	9	8	12	6
	Clinton	R	6	7	0	0
	Fayetteville	R	6	7	0 (3)	4
	Kingston	R	6	7	0 (2)	0
	Knoxville	P	5	5	0 (3)	2
	Lawrenceburg	R	NS	6	NS	5
	Nashville	P	5	6	0 (2)	2
	Pulaski	R	7	6	0 (2)	3
	Sequoyah	R	NS	7	NS	8
Tex:	Austin *	P	0	0	0	0
	Dallas *	P	3	4	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City *	P	0	2	0	1
Vt:	Burlington *	P	5	5	7 (2)	8
Va:	Norfolk *	P	6	5	0	3

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for July 1973 and 12-month period August 1972 through July 1973—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
Wash: Seattle [c]	P	0	2	0 (3)	1
Spokane [c]	P	4	4	0	0
Benton County	R				
Franklin County	R				
Longview	R				
Sandpoint, Idaho	R				
Skagit County	R				
W. Va: Charleston [c]	P	8	6	0	3
Wisc: Milwaukee [c]	P	8	5	12	3
Wyo: Laramie [c]	P	0	1	11	1
CANADA:					
Alberta: Calgary	P	NA		7	10
Edmonton	P	NA		9	14
British Columbia:					
Vancouver	P	NA		12	15
Manitoba: Winnipeg	P	NA		10	11
New Brunswick:					
Moncton	P	NA		9	9
Newfoundland:					
St. John's	P	NA		NS	
Nova Scotia:					
Halifax	P	NA		NS	
Ontario: Ottawa	P	NA		6	7
Sault Ste. Marie	P	NA		17	17
Thunder Bay	P	NA		NS	
Toronto	P	NA		5	7
Windsor	P	NA		6	7
Quebec: Montreal	P	NA		5	7
Quebec	P	NA		15	16
Saskatchewan:					
Regina	P	NA		3	8
Saskatoon	P	NA		4	8
CENTRAL AND SOUTH AMERICA:					
Canal Zone:					
Cristobal [c]	P	NS	0	NS	10
Chile: Santiago	P	3	1	0	0
Colombia: Bogota	P	NS	0	NS	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Kingston	P	NS	2	NS	41
Puerto Rico:					
San Juan [c]	P	3	1	0	2
Venezuela:					
Caracas	P	NS	0	NS	2
PMN network average [e]		5	5	5	3

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a month period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.
NS, no sample.

monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropri-

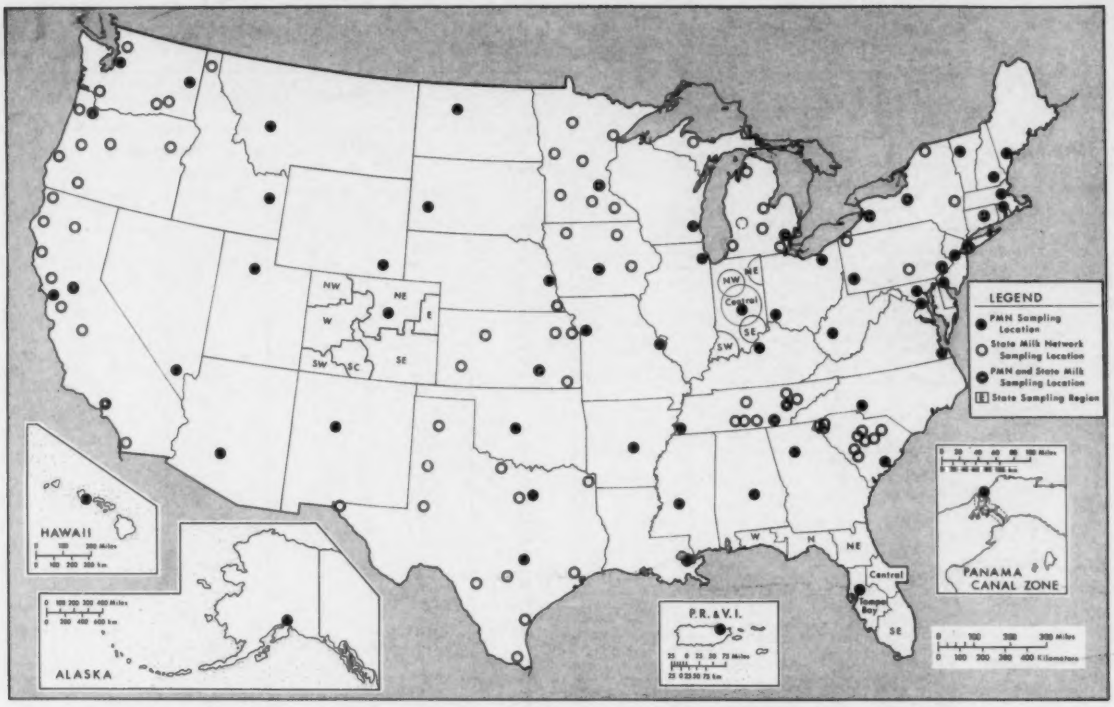

Figure 2. State and PMN sampling stations in the United States

ate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for July 1973 and the 12-month period, August 1972 to July 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at all of the stations for July 1973 were below the respective practical reporting levels.

Strontium-89 and iodine-131 results for individual samples were all below the respective practical reporting levels. Barium-140 results for individual samples were all below the practical reporting level with the following exception: Kansas, Coffeyville (State) 11 pCi/liter.

Strontium-90 monthly averages ranged from 0 to 26 pCi/liter in the United States for July 1973 and the highest 12-month average was 24 pCi/liter (Little Falls, Minn.) representing 12.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 67 pCi/liter in the United States for July 1973, and the highest 12-month average was 45 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report.

The Office of Radiation Programs is in the process of modifying the milk program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

Acknowledgment

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Environmental Control Component
Radiologic Health Section
California Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Department of Environmental Protection
Department of Health Laboratory Division
State of Connecticut

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina State Board of Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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(*2*) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

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(5) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

Milk Surveillance Network, June–July 1973

National Environmental Research Center-Las Vegas, Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV) consists of 24 routine and two alternate sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing conducted by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS).

In the event of a release of radioactivity from the NTS, special sampling within the affected

[1] This network is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

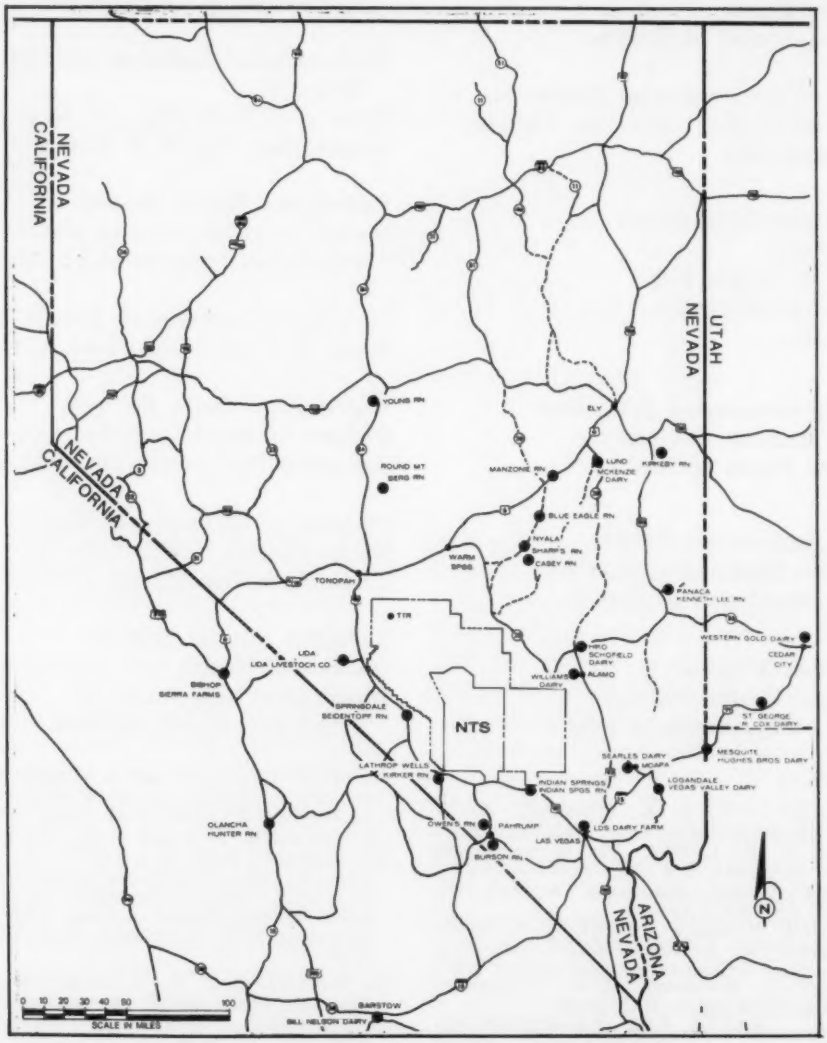

Figure 1. NERC-LV Milk Surveillance Network

area is conducted to determine radionuclide concentrations. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the July 1973 issue of *Radiation Data and Reports.*

Results

The analytical results of all milk samples collected in June and July 1973 by NERC-LV surveillance programs are listed in tables 1 and 2. With the exception of cesium-137 at levels near the minimum detectable activity (MDA) of 10 pCi/liter, no gamma-emitting fission products were identified by gamma spectrometry in any

Table 1. Milk surveillance results, June 1973

Location	Date collected (June 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Farms	14	11	<10	NA	NA	NA
Hinkley:						
Bill Nelson Dairy	13	12	<10	NA	NA	NA
Olancha:						
Hunter Ranch	13	13	<10	NA	NA	NA
Nevada:						
Alamo:						
Williams Dairy	11	12	<10	NA	NA	NA
Austin:						
Young's Ranch	13	13	<10	NA	NA	770±250
Currant:						
Blue Eagle Ranch	20	13	<100	NA	NA	NA
Manzonie Ranch	20	13	<10	NA	NA	NA
Hiko:						
Schofield Dairy	11	12	<10	NA	NA	<250
Indian Springs:						
Indian Springs Ranch	NS					
Las Vegas:						
LDS Dairy Farms	14	12	<10	NA	NA	<250
Lathrop Wells:						
Kirker Ranch	12	13	<10	NA	NA	NA
Lida:						
Lida Livestock Company	NS					
Logandale:						
Vegas Valley Dairy	11	12	<10	NA	NA	NA
Lund:						
McKenzie Dairy	13	12	<10	NA	NA	<250
Mesquite:						
Hughes Bros. Dairy	12	12	<10	NA	NA	<250
Moapa:						
Searles Dairy	12	12	<10	NA	NA	NA
Nyala:						
Sharp's Ranch	12	13	[c] <100	NA	NA	<250
Pahrump:						
Owens Ranch	13	13	<10	NA	NA	NA
Panaca:						
Kenneth Lee Ranch	12	13	<10	NA	NA	NA
Round Mountain:						
Berg Ranch	13	13	<10	NA	NA	NA
Shoshone:						
Kirkeby Ranch	17	13	<10	NA	NA	NA
Springdale:						
Seidentopf Ranch	13	13	<10	NA	NA	NA
Utah:						
Cedar City:						
Western Gold Dairy	12	12	<10	NA	NA	NA
St. George:						
R. Cox Dairy	13	12	<10	NA	NA	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, no analysis.
NS, no sample.

Table 2. Milk surveillance results, July 1973

Location	Date collected (July 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Farms	19	11	<10	<3.0	<2.0	NA
Hinkley:						
Bill Nelson Dairy	17	12	<10	<2.0	<1.4	NA
Olancha:						
Hunter Ranch	NS	13				
Nevada:						
Alamo:						
Williams Dairy	17	12	<10	<2.0	<1.5	NA
Austin:						
Young's Ranch	9	13	<10	<2.0	2.0±1.4	680±230
Currant:						
Blue Eagle Ranch	NS	13				
Manzonie Ranch	16	13	<10	<2.0	<1.3	NA
Hiko:						
Schofield Dairy	17	12	<10	<2.0	<1.3	<230
Indian Springs:						
Indian Springs Ranch	NS					
Las Vegas:						
LDS Dairy Farms	6	12	<10	<1.0	<1.0	<230
Lathrop Wells:						
Kirker Ranch	11	13	<10	<2.0	<1.1	NA
Lida:						
Lida Livestock Company	NS	13				
Logandale:						
Vegas Valley Dairy	2	12	<10	<2.0	<1.2	NA
Lund:						
McKenzie Dairy	17	12	<10	<2.0	1.9±1.4	<230
Mesquite:						
Hughes Bros. Dairy	2	12	<10	<2.0	<1.1	<230
Moapa:						
Searles Dairy	2	12	<10	<2.0	2.4±1.3	NA
Nyala:						
Sharp's Ranch	10	13	[c] <100	<2.0	2.3±1.3	<220
Pahrump:						
Owens Ranch	12	13	<10	<2.0	<1.1	NA
Panaca:						
Kenneth Lee Ranch	18	13	<10	<2.0	2.5±1.4	NA
Round Mountain:						
Berg Ranch	9	13	<10	<2.0	3.3±1.5	NA
Shoshone:						
Kirkeby Ranch	15	13	<10	<3.0	<2.3	NA
Springdale:						
Seidentopf Ranch	10	13	<10	<1.0	1.4±1.1	NA
Utah:						
Cedar City:						
Western Gold Dairy	3	12	<10	<2.0	<1.4	NA
St. George:						
R. Cox Dairy	3	12	<10	<2.0	1.4±1.2	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, no analysis.
NS, no sample.

of the samples collected in June. Levels of tritium near the MDA for this radionuclide (~200 pCi/liter) were also measured by liquid scintillation. The highest concentration of tritium during June was 770 ± 250 pCi/liter.

No gamma-emitting fission products were identified by gamma spectrometry in any of the samples collected in July. Levels of tritium and strontium-90 slightly above the MDA for these radionuclides (~200 pCi/liter and ~1 pCi/liter, respectively) were detected by liquid scintillation and radiochemistry procedures. The highest concentrations of these radionuclides during July were 680 ± 230 pCi–liter and 3.3 ± 1.5 pCi/liter, respectively.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1971	December 1972
Radiostrontium in Milk	January–December 1971	November 1972
Strontium-90 in Tri-City Diets	January–December 1971	December 1972

Carbon-14 in Total Diet and Milk, 1972–1973

Office of Radiation Programs
Environmental Protection Agency

In July 1965, a program to determine the levels of carbon-14 and tritium in the total diet and milk in the United States was initiated by the Public Health Service. In December 1970, this program was transferred to the Office of Radiation Programs of the Environmental Protection Agency (EPA). Initially, monthly samples from each of the EPA Institutional Total Diet Sampling Network (ITDSN) and Pasteurized Milk Network (PMN) stations were composited and analyzed according to six arbitrarily selected regions: Northeast, South, Delta, Central, Southwest, and Northwest. Figure 1 shows the ITDSN and PMN sampling stations in each of the designated regions.

In January 1966, the program was modified to include selected stations in each of the previously mentioned regions plus Alaska and Hawaii. The nine geographically distributed sampling stations are: Palmer, Alaska; Honolulu, Hawaii; Idaho Falls, Idaho; Chicago, Ill.; New Orleans, La.; Boston, Mass.; Portland, Oreg.; and Charleston, S.C. Los Angeles, Calif., is not a PMN station, but a special milk sample is collected monthly for purposes of comparison with the routine ITDSN sample.

A 1-liter milk sample and a 2-kilogram food sample are sent to the National Environmental Research Center-Las Vegas for analysis. The milk and total diet samples analyzed represent the samples collected for that month.

The carbon-14 analyses are performed semiannually. The tritium analyses were discontinued in July 1969 because the results were only slightly above the limit of detectability and were less than 1 percent of the maximum permissible concentration for milk and food consumed by the general population.

The carbon-14 content is determined by combustion of the milk or food sample and collection and purification of the evolved carbon dioxide. The carbon dioxide is then converted to benzene and counted in a liquid scintillation spectrometer.

Results and discussion

The carbon-14 concentrations in total diet and milk are shown in table 1 as dpm/g C and pCi/kg or pCi/liter. This is the final data presentation of carbon-14 in total diet since the ITDSN was discontinued in June 1973, and a summary of the mean carbon-14 concentrations

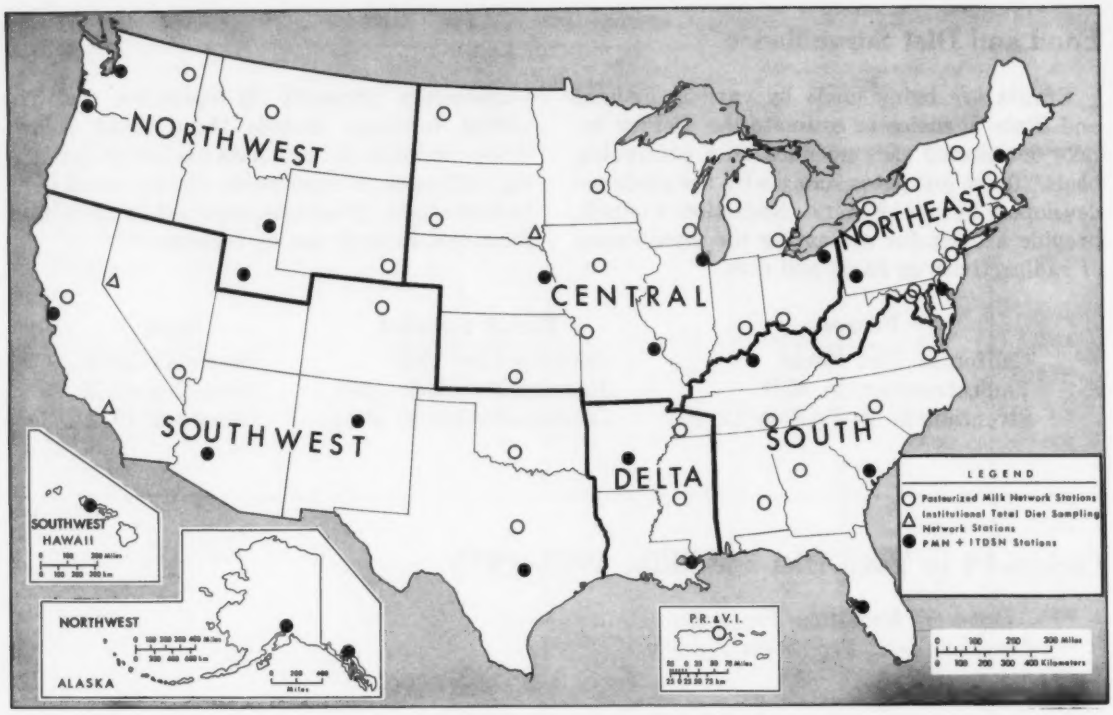

Figure 1. ITDSN and PMN sampling stations

Table 1. Carbon-14 in total diet and milk, 1972-1973

Location	Date collected	Total diet		Milk	
		(dpm/g C ±2σ)	(pCi/kg ±2σ)	(dpm/g C ±2σ)	(pCi/liter ±2σ)
Alaska: Palmer	April 1972	NS	NS	19.2±0.9	460±20
	Dec 1972	18.4±0.7	910±30		
	Jan 1973			18.8± .8	470±20
	April 1973	NS	NS	16.0± .7	450±20
Calif: Los Angeles	April 1972	NS	NS	16.6± .6	430±20
	Oct 1972	NS	NS		
	Jan 1973			17.5± .6	430±20
	April 1973	NS	NS	16.9± .8	500±20
Hawaii: Honolulu	April 1972	14.6± .6	620±20	NS	NS
	Oct 1972	15.6± .8	640±40		
	Jan 1973			16.2± .7	410±20
	April 1973	16.1± .7	740±30	19.0± .7	650±20
Idaho: Idaho Falls	April 1972	14.0± .6	580±20	16.0± .5	540±20
	Jan 1973	16.6± .7	750±30	19.4± .7	490±20
	April 1973	NS	NS	14.3±1.0	330±30
Ill: Chicago	April 1972	18.8± .7	860±30	NS	NS
	Oct 1972	NS	NS	17.6± .6	610±20
	April 1973	NS	NS	NS	NS
La: New Orleans	April 1972	14.8± .7	690±30	NS	NS
	Oct 1972			13.8± .5	360±20
	Jan 1973	15.2± .7	700±30		
	April 1973	18.1± .6	460±30	NS	NS
Mass: Boston	April 1972	15.9± .5	720±30	19.2± .8	390±10
	Nov 1972			16.9± .6	470±20
	Jan 1973	15.4±1.0	560±40		
	April 1973			17.0± .7	510±20
	May 1973	18.9± .9	780±30		

Table 1. Carbon-14 in total diet and milk, 1972-1973—continued

Location	Date collected	Total diet		Milk	
		(dpm/g C ±2σ)	(pCi/kg ±2σ)	(dpm/g C ±2σ)	pCi/liter ±2)
Oreg: Portland	April 1972	NS	NS	18.9± .8	490±20
	Oct 1972	20.0± .7	660±20		
	Jan 1973			17.8± .8	510±20
	April 1973	18.6± .7	710±30	16.4± .6	510±20
S.C: Charleston	April 1972	19.8± .7	790±30	16.9±1.4	320±30
	Oct 1972	NS	NS	17.6± .6	510±20
	April 1973	NS	NS	19.4± .7	570±20

NS, no sample.

Table 2. Summary of the mean carbon-14 concentrations in total diet and milk for all stations

Date collected	Total diet[a]		Milk[a]	
	(dpm/g C)	(pCi/kg)	(dpm/g C)	(pCi/liter)
July-December 1965		1,120 (920–1,380)		570 (450– 760)
January-June 1966		1,100 (800–1,510)		610 (490– 710)
July-December 1966		1,200 (770–1,470)		555 (350– 690)
January-June 1967		1,290 (1,150–1,450)		680 (480–1,040)
July-December 1967		1,170 (1,130–1,450)		570 (390– 790)
January-June 1968		1,160 (1,020–1,280)		550 (390– 740)
July-December 1968		1,030 (770–1,170)		500 (360– 630)
January-June 1969		1,020 (850–1,160)		500 (460– 560)
July-December 1969		1,000 (880–1,140)		490 (460– 510)
January-June 1970		890 (780–1,040)		470 (460– 520)
July-December 1970		820 (780– 860)		430 (410– 470)
January-June 1971	17.23 (15.92–18.48)	800 (740– 860)	16.90 (15.07–18.37)	430 (380– 460)
July-December 1971	17.22 (15.35–18.27)	750 (670– 800)	15.85 (14.50–17.14)	390 (360– 420)
January-June 1972	16.8 (14.0 –19.8)	710 (580– 860)	17.8 (16.0 –19.2)	440 (320– 540)
July-December 1972	18.0 (15.6 –20.0)	740 (640– 910)	16.2 (13.8 –17.6)	490 (360– 610)
January-June 1973	17.0 (15.2 –18.9)	670 (460– 780)	17.4 (14.3 –19.4)	490 (330– 650)

[a] Range of carbon-14 values given in parentheses.

for 1965–1973 is shown in table 2. Carbon-14 measurements in milk will continue with an annual analysis performed in April of each year.

It is interesting to note that carbon-14 concentrations in food have decreased more rapidly than the carbon-14 concentrations in milk. The Federal Radiation Council (*1*) predicted that the carbon-14 produced by atmospheric nuclear weapons tests would "be removed from the atmosphere by exchange with the ocean with a rate corresponding to a half-time of about 33 years." The data in table 2 indicate that it is being removed from food with a half-time rate of about 6 years.

REFERENCE

(*1*) FEDERAL RADIATION COUNCIL. Estimates and evaluation of fallout in the United States from nuclear weapons testing conducted through 1962, Report No. 4. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1963).

Other coverage in *Radiation Data and Reports:*

Period	Issue
July 1965–December 1968	November 1969
January 1969–June 1970	January 1971
July–December 1970	May 1971
January–June 1971	December 1971
July–December 1971	May 1972

Radionuclides in Institutional Diet Samples, January–March 1973

Environmental Protection Agency and Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education, and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present 26 institutions—distributed geographically as shown in figure 1—are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1, 2*). Extrapolating this information, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water—which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice and shipped by air to either the National Environmental Research Center, Las Vegas, Nev. or the Eastern Environmental Radiation Facility, Montgomery, Ala. A detailed description

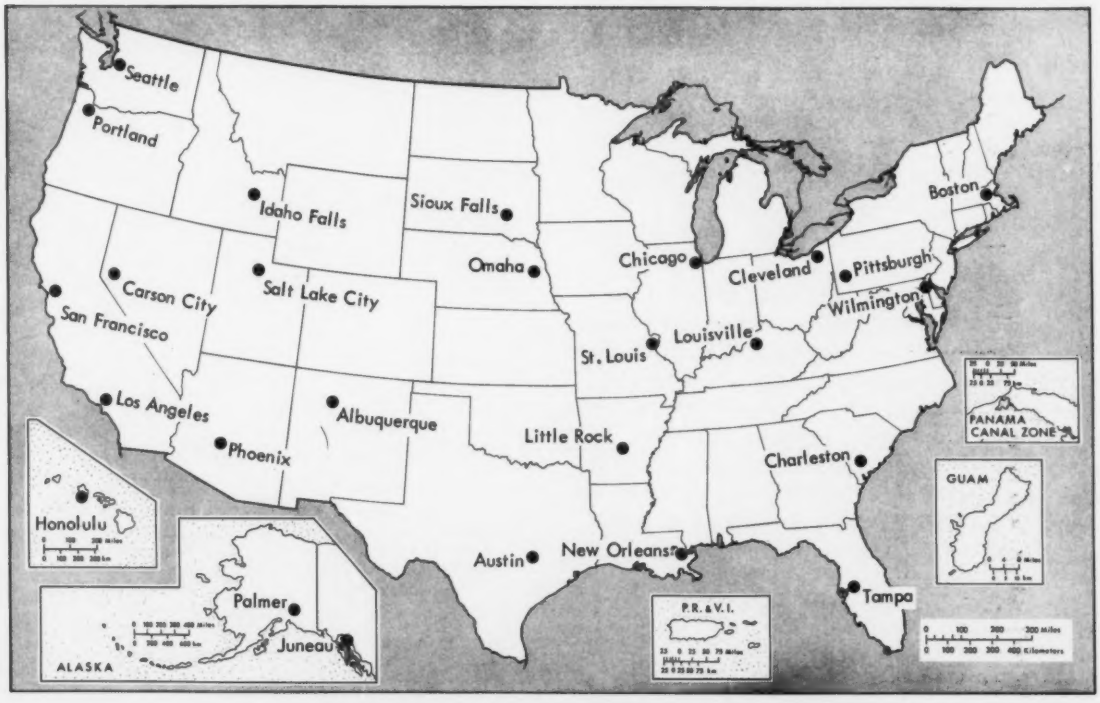

Figure 1. Institutional diet sampling locations as of March 1973

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children January-March 1973

Location of institution	Month[a] (1973)	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	Jan	2.46	0.5	1.3	1.4	3.4	5	12	0	0
Palmer	Feb	1.76	.6	1.0	2.0	3.6	3	5	68	120
Ariz: Phoenix	Jan	1.25	.4	.6	1.5	1.9	6	8	0	0
Ark: Little Rock	Jan[b]	1.25	.5	.7	1.8	2.3	5	7	0	0
Calif: Los Angeles	NS									
San Francisco	Jan[b]	1.58	.5	.7	1.8	2.9	4	6	0	0
Del: Wilmington	Jan[b]	.93	.6	.6	1.1	1.0	4	4	0	0
Fla: Tampa	Jan	1.83	.5	.9	1.2	2.2	4	7	14	26
Hawaii: Honolulu	Jan	2.14	.4	.9	1.6	3.5	6	12	0	0
Idaho: Idaho Falls	Jan[b]	1.29	.6	.8	1.6	2.1	0	0	0	0
Ill: Chicago	NS									
Ky: Louisville	Jan	2.18	1.0	2.3	1.5	3.3	6	13	0	0
La: New Orleans	Jan[b]	1.66	.5	.8	1.7	2.9	6	10	0	0
Mass: Boston	Jan	2.62	.6	1.6	1.3	3.4	5	12	0	0
Mo: St. Louis	Jan	.91	.5	.5	1.4	1.3	4	4	0	0
Nebr: Omaha	Jan[b]	1.85	.6	1.2	1.5	2.9	9	16	0	0
Nev: Carson City	Jan	1.32	.6	.8	1.7	2.3	0	0	0	0
N. Mex: Albuquerque	Jan[b]	1.84	.7	1.3	2.0	3.7	4	6	0	0
Ohio: Cleveland	Jan[b]	.94	.7	.6	1.7	1.6	6	6	17	16
Oreg: Portland	Jan[b]	2.24	.6	1.3	2.0	4.5	3	7	0	0
Pa: Pittsburgh	Jan	3.12	.4	1.2	1.2	3.6	4	12	0	0
S.C: Charleston	Jan	1.88	.8	1.6	1.4	2.7	5	10	00	0
S. Dak: Sioux Falls	Jan	1.16	.6	.7	1.7	2.0	6	7	0	0
Tex: Austin	Jan[b]	1.29	.6	.8	2.0	2.6	3	4	0	0
Utah: Salt Lake City	Jan[b]	2.04	.5	1.1	1.4	2.9	2	4	0	0
Wash: Seattle	Jan[b]	1.49	.4	.7	1.7	2.6	3	4	0	0
Institutional average		1.71	0.6	1.0	1.6	2.7	4	7	4	7

[a] Quarterly sample usually collected the first month of the quarter.
[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.
Note: Iodine-131, barium-140, and strontium-89 were not detected at any station during this period.
NS, no sample.

of sampling and analytical procedures has already been presented in *Radiological Health Data and Reports.*

Results

Table 1 shows the analytical results for institutional diet samples collected from all stations during January–March 1973. The stable elements, calcium and potassium, are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.71 kg/day compared to the network average of 1.84 kg/day observed from 1961 through 1972.

Strontium-90 dietary intake averaged 7 pCi/day during this period. Cesium-137 intake averaged 7 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (*4*). Strontium-89, barium-140, and iodine-131 concentrations were below detectable levels.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2 standard deviation analytical error. Accordingly, the minimum detectable limits are strontium-89, 5 pCi/kg; strontium-90, 2 pCi/kg; iodine-131, 10 pCi/kg; barium-140 10 pCi/kg; and cesium-137, 10 pCi/kg.

REFERENCES

(*1*) ANDERSON, E. C., D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data Rep 6:548–554 (Octobr 1965).

(*3*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–March 1972	June 1973
April–June 1972	July 1973
July–September 1972	August 1973
October–December 1972	September 1973

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
Colorado River Basin	1968	March 1972
Community Water Supply Study	1968	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January–December 1971	February 1973
Michigan	January–June 1970	November 1971
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	July–December 1971	November 1972
Tritium Surveillance System	April–June 1973	October 1973
Washington	July 1970–June 1971	August 1973
Water Surveillance Programs, *NERC-LV*	April–May 1973	October 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Programs, June–July 1973

National Environmental Research Center-
Las Vegas
Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 61 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs conducted by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

In the event of a release of radioactivity from

[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

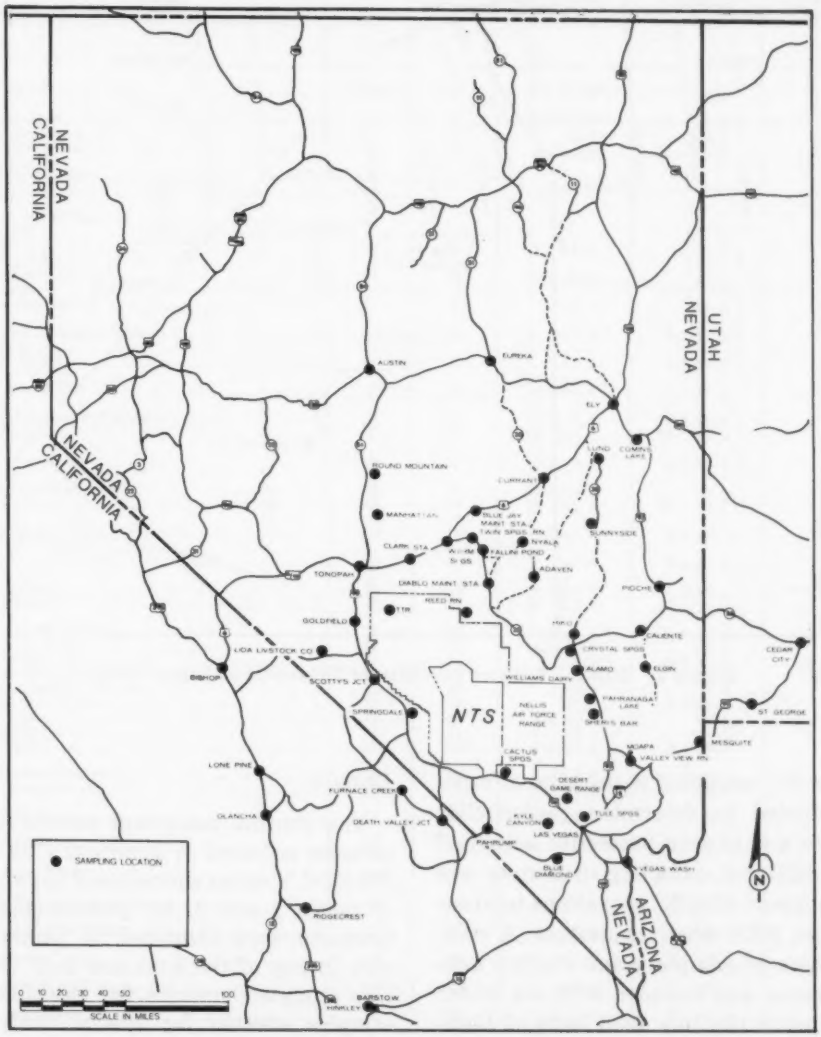

Figure 1. NERC-LV Water Surveillance Network

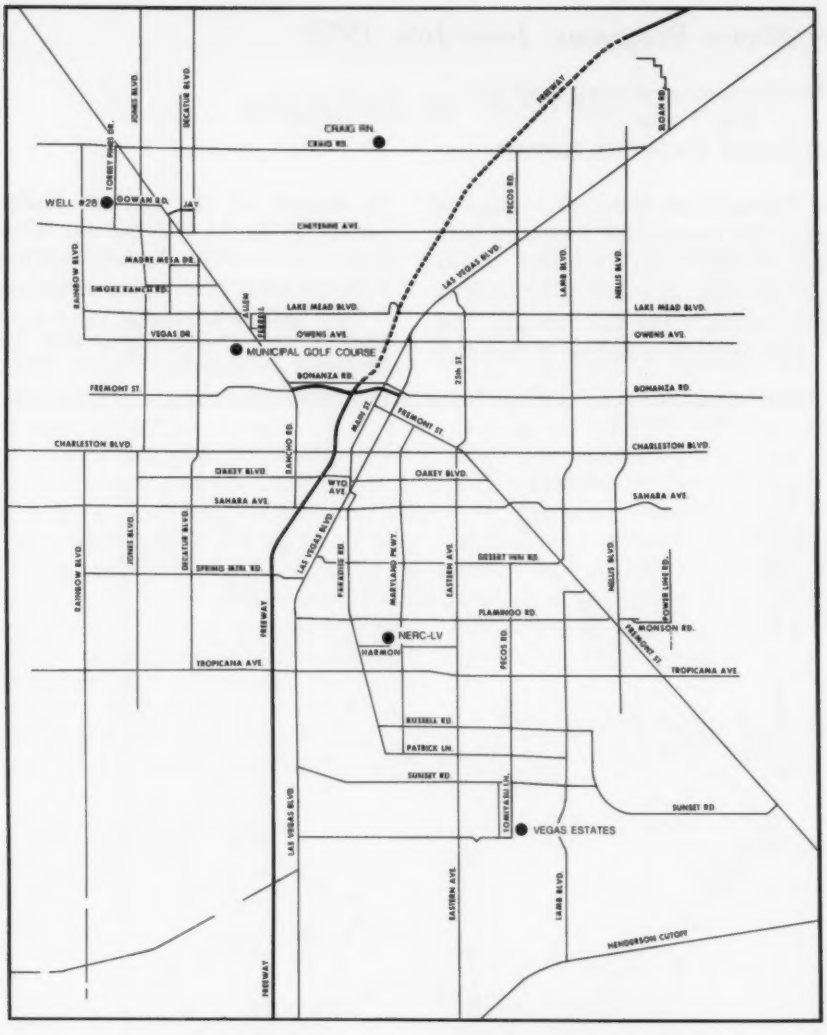

Figure 2. NERC-LV Water Surveillance Network, Las Vegas Valley

the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the July 1973 issue of *Radiation Data and Reports.*

Results

The routine analytical results of all water samples collected in June and July 1973 by the NERC-LV water surveillance network are listed in tables 1 and 2. No gamma-emitting fission products were identified by gamma spectrometry in any of the June and July 1973 samples. The analytical results for calendar year 1973 samples selected for special analyses will be reported at a later date.

Table 1. Water surveillance results, June 1973

Location	Date collected (June 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	14	23	<1.4	<3.3	NA
Death Valley Junction:					
Lila's Cafe	14	23	<4.3	6.8±3.9	<240
Furnace Creek:					
Pond	14	21	<3.2	7.8±3.8	NA
Visitor Center	14	27	<2.0	7.5±3.8	NA
Hinkley:					
Bill Nelson Dairy	13	23	7.6±4.7	6.5±3.6	NA
Lone Pine:					
Forest Service Ranger Station	13	23	<1.5	<3.4	NA
Olancha:					
Haiwee Reservoir	13	21	4.3±2.8	<3.4	NA
Ridgecrest:					
City Hall	13	23	4.5±3.6	<3.4	NA
Nevada:					
Adaven:					
Canfield Ranch	12	22	3.5±2.6	<3.4	NA
Alamo:					
Pahranagat Lake	11	21	8.0±5.0	17 ±4.2	NA
Sheri's Bar	11	23	<2.2	<3.4	NA
Williams Dairy	11	23	4.5±3.8	12 ±4.0	NA
Ash Meadows:					
Ash Meadows Lodge	NS				
Pond	NS				
Austin:					
Nevada National Bank	NS				
Blue Diamond:					
Post Office	12	23	5.0±3.6	<3.6	<250
Blue Jay Highway:					
Maintenance Station	14	23	4.5±3.3	<3.4	NA
Cactus Springs:					
Mobil Service Station	11	27	<2.0	<3.3	<240
Caliente:					
Agricultural Extension Station	13	23	7.5±4.0	4.1±3.4	NA
Clark Station:					
Five Mile Ranch	14	27	<1.3	5.7±3.5	NA
Currant:					
Currant Ranch Cafe	19	27	6.0±4.0	3.7±3.4	NA
Diablo:					
Highway Maintenance Station	12	23	<2.2	5.7±3.6	NA
Reed Ranch	11	21	13 ±5.7	19 ±4.3	NA
Elgin:					
Water tower	13	23	5.1±4.0	5.6±3.6	NA
Ely:					
Chevron Service Station	18	24	4.4±2.9	<3.3	NA
Comins Lake	18	21	15 ±6.6	27 ±4.7	NA
Eureka:					
Highway Maintenance Station	1	24	4.7±3.3	6.8±3.5	NA
Goldfield:					
Chevron Service Station	13	23	<3.0	3.5±3.5	NA
Hiko:					
Crystal Springs	11	27	7.8±4.0	4.9±3.4	NA
Schofield Dairy	11	23	23 ±7.9	23 ±4.5	NA
Las Vegas:					
Craig Ranch Golf Course	11	23	4.8±3.0	<3.5	<250
Desert Game Range	11	24	4.0±2.8	<3.5	<250
Lab II NERC	11	24	<3.4	6.3±3.6	700±250
Lake Mead Vegas Wash	11	21	<3.4	<3.4	640±260
Las Vegas District Well 28	11	23	<2.1	<3.3	<250
Municipal Golf Course	11	23	<2.2	4.4±3.3	<250
Tule Springs	11	23	4.3±2.8	<3.5	<250
Tule Springs Pond	11	21	2.4±2.1	<3.5	NA
Vegas Estates	12	23	4.2±4.0	8.7±3.7	<250
Lida:					
Lida Livestock Company	10	27	4.4±3.2	<3.4	NA
Pond at storage tank	10	21	3.0±2.5	<3.3	NA
Lund:					
Gardner Grocery	19	23	2.9±2.8	<3.3	NA
Manhattan:					
Country store	14	23	20 ±7.1	<3.5	NA
Mesquite:					
Hughes Bros. Dairy	12	23	6.1±5.8	15 ±4.5	NA
Moapa:					
Pedersen Valley View Ranch	12	27	6.9±4.8	8.0±3.8	NA
Mt. Charleston:					
Kyle Canyon Fire Station	11	27	2.5±2.4	<3.3	<250
Nyala:					
Sharp's Ranch	12	23	<1.9	<3.4	NA
Pahrump:					
Texaco Service Station	13	23	<1.5	<3.4	NA
Pioche:					
County courthouse	12	24	2.8±2.4	3.4±3.3	NA

See footnotes at end of table.

Table 1. Water surveillance results, June 1973—continued

Location	Date collected (June 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Round Mountain:					
Mobil Service Station	14	27	2.5±2.1	<3.3	NA
Scotty's Junction:					
Chevron Service Station	10	23	4.3±4.1	12 ±4.0	<240
Springdale:					
Pond	18	21	<3.1	11 ±3.9	NA
Sunnyside:					
Adam McGill Reservoir	19	21	7.6±4.3	5.9±3.5	NA
Wildlife Management Headquarters	19	27	<2.4	3.6±3.4	NA
Tonopah:					
Jerry's Chevron Station	13	23	5.8±3.6	5.9±3.6	NA
Tonopah Test Range CP–1	13	23	<3.1	4.0±3.5	NA
Warm Springs:					
Fallini's Pond	12	21	19 ±9.0	49 ±6.0	NA
Service Station and Cafe	14	27	22 ±8.8	29 ±4.9	NA
Twin Springs Ranch	14	23	8.5±4.5	9.5±3.7	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	13	24	<2.0	<3.3	NA
St. George:					
R. Cox Dairy	13	24	1.6±1.5	<3.3	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply-mixed water sample consisting of mixed or multiple sources of water, such as well or spring.
27—Spring.

[b] Two-sigma counting error provided when available.
NA, no analysis.
NS, no samples.

Table 2. Water surveillance results, July 1973

Location	Date collected (July 1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	19	23	<1.4	<3.5	NA
Death Valley Junction:					
Lila's Cafe	20	23	<3.9	8.0±4.0	<230
Furnace Creek:					
Pond	20	21	<3.2	7.7±3.8	NA
Visitor Center	20	27	<4.1	6.0±3.7	NA
Hinkley:					
Bill Nelson Dairy	17	23	9.0±5.8	<3.6	NA
Lone Pine:					
Forest Service Ranger Station	19	24	<1.7	<3.5	NA
Olancha:					
Haiwee Reservoir	18	21	<1.5	<3.5	NA
Ridgecrest:					
City Hall	18	23	<3.5	<3.5	NA
Nevada:					
Adaven:					
Canfield Ranch	11	22	<3.2	<3.5	NA
Alamo:					
Pahranagat Lake	17	21	12 ±6.6	20 ±4.5	NA
Sheri's Bar	17	23	<2.9	<3.5	NA
Williams Dairy	17	23	<4.2	9.2±3.9	NA
Austin:					
Nevada National Bank	NS	27			
Blue Diamond:					
Post Office	5	23	<3.2	<3.7	<240
Blue Jay Highway:					
Maintenance Station	10	23	<2.5	3.9±3.5	NA
Cactus Springs:					
Mobil Service Station	9	27	<2.0	<3.3	<230
Caliente:					
Agricultural Extension Station	18	23	<3.4	<3.5	NA
Clark Station:					
Five Mile Ranch	10	27	<2.8	7.8±3.8	NA
Currant:					
Currant Ranch Cafe	17	27	6.9±5.2	<3.6	NA

See footnotes at end of table.

Table 2.—Water surveillance results, July 1973—continued

Location	Date collected July (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Nevada—continued					
Diablo:					
Highway Maintenance Station	9	23	<2.7	6.3±3.7	NA
Reed Ranch	9	21	13 ±6.0	7.0±3.7	NA
Elgin:					
Water tower	19	23	5.8±4.9	8.0±3.8	NA
Ely:					
Chevron Service Station	17	24	<2.4	<3.5	NA
Comins Lake	16	21	7.4±5.6	28 ±4.9	NA
Eureka:					
Highway Maintenance Station	2	24	<2.6	<3.6	NA
Goldfield:					
Chevron Service Station	9	24	7.6±5.1	8.3±3.7	NA
Hiko:					
Crystal Springs	17	27	8.4±4.5	3.7±3.5	NA
Schofield Dairy	17	23	26 ±8.6	28 ±4.8	NA
Las Vegas:					
Craig Ranch Golf Course	5	23	6.1±3.7	<3.6	<230
Desert Game Range	5	23	3.2±2.8	<3.6	<230
Lab II NERC	5	24	<3.7	6.3±3.9	880±250
Lake Mead Vegas Wash	5	21	<3.0	<3.7	900±250
Las Vegas Water District Well 28	6	23	2.7±2.6	<3.6	<230
Municipal Golf Course	6	23	3.3±2.8	<3.6	<230
Tule Springs	5	23	3.1±2.6	<3.6	<230
Tule Springs Pond	5	21	2.3±2.2	<3.6	NA
Vegas Estates	5	23	<4.2	7.1±3.9	<230
Lida:					
Lida Livestock Company	9	27	<3.0	<3.5	NA
Pond at storage tank	9	21	<2.2	<3.5	NA
Lund:					
Gardner Grocery	18	23	<2.5	<3.5	NA
Manhattan:					
Country store	10	23	9.9±5.6	<3.4	NA
Mesquite:					
Hughes Bros. Dairy	2	23	<5.9	19 ±5.0	NA
Moapa:					
Pedersen Valley View Ranch	2	27	<3.9	4.3±3.8	NA
Mt. Charleston:					
Kyle Canyon Fire Station	5	27	<1.7	<3.6	<230
Nyala:					
Sharp's Ranch	10	23	<2.8	<3.5	NA
Pahrump:					
Texaco Service Station	10	23	<2.8	<3.3	NA
Pioche:					
County courthouse	18	24	<2.1	<3.5	NA
Round Mountain:					
Mobil Service Station	10	27	<2.3	<3.5	NA
Scotty's Junction:					
Chevron Service Station	9	23	<5.7	4.8±3.7	<220
Springdale:					
Pond	10	21	<4.0	6.8±3.7	NA
Sunnyside:					
Adam McGill Reservoir	18	21	<3.1	4.9±3.6	NA
Wildlife Management Headquarters	18	27	<2.5	<3.5	NA
Tonopah:					
Jerry's Chevron Station	11	23	<3.3	<3.5	NA
Tonopah Test Range CP-1	11	23	<3.0	4.2±3.6	NA
Warm Springs:					
Fallini's Pond	11	21	13 ±8.8	40 ±5.7	NA
Service Station and Cafe	10	27	18 ±9.0	20 ±4.6	NA
Twin Springs Ranch	10	23	4.5±4.2	7.3±3.7	NA
Utah:					
Cedar City:					
M. D. Baldwin residence	3	24	<1.6	<3.6	NA
St. George:					
R. Cox Dairy	3	24	2.4±1.9	<3.6	NA

[a] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water such as well and spring).
27—Spring.

[b] Two-sigma counting error provided when available.
NA, not analyzed.
NS, no sample.

Radioactivity in California Waters,[1] January–December 1971 and January–December 1972

Radiologic Health Section, State of California Department of Health

The Radiologic Health Section of the California State Department of Health has maintained a program of domestic water sampling for radioanalyses since 1960. The source of radionuclides in water supplies includes the natural radioactivity, the contribution from fallout, and in a few instances, the activity added by sewage discharges and industrial effluents. The California Domestic Water Network stations are shown in figure 1.

The monitoring program consists primarily of monthly sampling of domestic water at the point of consumption (at the tap) and analyzing them for gross beta radioactivity. Fourteen of the 20 locations are surface water supplies, three are wells, two are Ranney wells, and one is a spring.

[1] Data from State of California, Department of Health, Radiologic Health Section, 744 P Street, Sacramento, Calif. 95814.

Figure 1. California domestic water network

The purpose of this program is to determine the radioactivity of the water. Water processed in any manner that might remove radioactivity therefrom is defined herein as treated water. Thus, a water treatment plant that employs coagulation, sedimentation, filtration, or similar processes is considered for our purposes to produce treated water. Chlorination is not considered as treatment from a radiological viewpoint. Well waters, including springs and Ranney wells, are usually pumped directly to the distribution system with nothing more than chlorination, and are considered as raw water. It is not implied by the use of the words "raw" and "treated" that the waters are not potable or bacterially safe.

Under the present sampling schedule, monthly 500 milliliter samples are collected by the purveyor of 20 water supplies and sent to the Sanitation and Radiation Laboratory at Berkeley. In addition, the purveyor collects a yearly composite which is analyzed for specific radionuclides.

Analytical procedures

Radioanalyses of the water samples are made by the Sanitation and Radiation Laboratory of the State Department of Health. Measurements of gross beta radioactivity on the monthly samples are made by evaporating the samples to dryness and analyzing the solids for gross beta radioactivity in a windowless, gas-flow proportional counter. The yearly composites are collected throughout the year to make a 5-gallon sample. The entire sample is reduced to dryness. A gamma scan is made on the dry solids with a 10- by 10-cm (4- by 4-inch) sodium iodide (thallium activated) detector. Eight radionuclides are determined. Radiochemical analyses are performed to obtain radium and strontium-90 values. Analytical procedures are those recommended by the Environmental Protection Agency (*1*).

Sewage samples

Sewage samples are collected from 20 treatment plants throughout the State (figure 2). Many of the cities used as sampling locations in this program are the same as those in the domestic water sampling program. Results of analyses of sewage effluent and sludge samples provide a means of assuring that industrial radioactive wastes discharged into sewage systems do not become excessive. The surveillance of sewage assumes greater importance as isotope licenses become more numerous and as the quantity of radioactive material per user in-

Table 1. Gross beta radioactivity in California domestic waters, January-December 1971

Sampling station	Type [a]	Concentration (pCi/liter)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Antioch	Treated	3	13	3	0	NS	NS	8	0	4	25	NS	1
Berkeley	Treated	6	6	1	9	1	5	3	6	4	2	0	2
Crescent City	Ranney well	NS	NS	NS	NS	1	4	4	2	NS	12	5	0
Death Valley	Spring	NS	NS	NS	NS	16	322	3	5	NS	28	26	NS
El Centro	Treated	23	NS	14	22	22	0	14	16	20	0	31	NS
Eureka	Well	2	NS	12	6	2	6	7	7	10	3	0	6
Lake Arrowhead	Raw	NS	1	NS	NS	5	11	3	11	NS	23	18	NS
Livermore	Well	0	0	0	0	4	NS	0	11	8	11	0	0
Los Angeles	Raw	10	6	0	17	20	18	NS	3	101	0	3	10
Marin Municipal Water District	Treated	3	0	10	1	6	4	2	5	13	3	9	3
Metropolitan Water District of Southern Calif	Treated	20	26	11	44	32	62	72	55	11	34	3	25
Pleasanton	Well	0	12	0	11	0	14	34	5	0	9	6	0
Redding	Treated	NS	NS	NS	NS	3	4	11	13	22	3	5	1
Sacramento	Treated	10	7	5	1	0	2	13	NS	4	NS	NS	0
San Diego	Treated	10	20	17	66	4	19	14	9	55	4	6	3
San Francisco	Raw	2	9	4	0	6	7	6	15	41	0	6	1
San Luis Obispo	Treated	NS	NS	NS	NS	14	10	0	NS	NS	11	16	10
Santa Barbara	Treated	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	15
Santa Rosa	Ranney well	29	10	43	1	0	2	1	8	2	1	1	0
Salinas	Well	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a] Treated water means complete treatment, (note: chlorination is not considered as treatment); the use of words raw and treated does not imply the waters are not potable or not bacterially safe. The word "treated" implies that the water has been processed and has possibly changed the radioactive content of the water.

NS, no sample.

Table 2. Gross beta radioactivity in California domestic waters, January-December 1972

Sampling station	Type *	Concentration (pCi/liter)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Antioch	Treated	7	12	0	0	2	0	0	0	0	2	20	0
Berkeley	Treated	1	0	2	6	3	0	1	11	1	0	3	0
Crescent City	Ranney well	9	1	0	3	0	8	11	16	0	2	1	0
Death Valley	Spring	13	NS	55	18	56	3	11	24	0	NS	8	15
El Centro	Treated	7	NS	19	NS	0	5	7	17	1	0	0	21
Eureka	Treated	0	11	9	0	2	0	10	0	30	0	7	NS
Lake Arrowhead	Raw	0	6	3	105	0	1	4	7	3	0	20	8
Livermore	Well	0	0	1	0	0	0	4	5	0	2	15	5
Los Angeles	Raw	19	13	0	1	0	15	28	12	5	3	0	32
Marin Municipal Water District	Treated	0	12	0	4	16	0	11	19	0	4	1	0
Metropolitan Water District of Southern Calif	Treated	17	11	18	4	14	3	32	28	0	57	45	18
Pleasanton	Well	0	0	0	0	0	13	5	16	1	10	7	69
Redding	Treated	15	9	8	4	5	0	2	2	0	10	16	0
Sacramento	Treated	10	NS	NS	0	3	0	7	0	0	3	1	11
Salinas	Well	19	3	6	3	18	5	0	10	0	11	0	12
San Diego	Treated	5	27	11	3	18	5	12	0	19	10	7	0
San Francisco	Raw	0	10	0	0	6	6	12	8	0	8	4	8
San Luis Obispo	Treated	6	5	8	4	23	0	2	26	11	20	0	17
Santa Barbara	Treated	1	15	2	1	0	15	0	0	0	5	0	3
Santa Rosa	Ranney well	0	14	15	0	4	5	5	0	1	9	NS	0

* Treated water means complete treatment, (note: chlorination is not considered as treatment); the use of words raw and treated does not imply the waters are not potable or not bacterially safe. The word "treated" implies that the water has been processed and has possibly changed the radioactive content of the water.

NS, no sample.

Table 3. Radionuclides in California domestic waters, January-December 1971

Sampling station	Radionuclide concentration (pCi/liter)							
	Radium-226	Potassium-40	Manganese-54	Zirconium-niobium-95	Cesium-137	Cerium-141, -144	Strontium-89	Strontium-90
Antioch	0.04	1.91	0.2	0.4	0.2	0.2	0.0	0.2
Berkeley	.01	1.39	.3	.2	.3	.1	.0	.2
Death Valley	.05	6.01	.0	.0	.2	.0	.0	.1
Eureka	.02	1.06	.1	.2	.0	.1	.0	.2
Los Angeles	NS	NS	NS	NS	NS	NS	NS	NS
Marin Municipal Water District	.02	1.13	.2	.6	.3	.1	.0	.2
Metropolitan Water District of Southern Calif	.07	2.87	.2	.8	.1	.2	.0	.8
Pleasanton	NS	NS	NS	NS	NS	NS	NS	NS
Redding	.01	1.14	.0	.2	.1	.0	.0	.2
Sacramento	.02	.71	.0	.0	.2	.2	.0	.3
Salinas	NS	NS	NS	NS	NS	NS	NS	NS
San Diego	NS	3.44	.1	.0	.2	.1	.0	1.4
San Francisco	.02	1.56	.3	1.0	.4	.2	.0	.5
San Luis Obispo	.03	3.49	.1	.0	.4	.0	.0	.7
Santa Barbara	NS	NS	NS	NS	NS	NS	NS	NS
Santa Rosa	.02	.20	.9	13.1	.6	.1	.0	.1

Table 4. Radionuclides in California domestic waters, January-December 1972

Sampling station	Radionuclide concentration (pCi/liter)							
	Radium-226	Potassium-40	Manganese-54	Zirconium-niobium-95	Cesium-137	Cerium-141, -144	Strontium-89	Strontium-90
Antioch	0.05	2.38	0.0	0.0	0.0	0.0	0.0	0.2
Berkeley	.01	2.79	.3	.6	.0	.1	.0	.3
Death Valley	.06	8.01	.4	.3	.1	.4	.0	.0
Eureka	.03	1.01	.2	.3	.0	.3	.0	.1
Los Angeles	.03	4.80	.4	.0	.0	.4	.0	.1
Marin Municipal Water District	.02	2.84	.4	1.9	.2	.2	.0	.2
Metropolitan Water District of Southern Calif	.09	4.57	.2	.1	.1	.3	.0	1.7
Pleasanton	.05	3.22	.0	.7	.0	.3	.0	.0
Redding	.00	2.46	.3	1.3	.3	.4	.0	.1
Sacramento	.02	2.41	.2	.4	.1	.2	.0	.2
Salinas	.09	3.15	.4	.8	.1	.6	.0	.0
San Diego	NS	6.06	.1	1.0	.1	.5	.0	1.3
San Francisco	.02	1.12	.1	.6	.3	.2	.0	.4
San Luis Obispo	.03	3.53	.0	.6	.0	.1	.0	.5
Santa Barbara	.05	2.45	.2	.0	.1	.3	.0	.2
Santa Rosa	.02	1.03	.1	.3	.0	.2	.0	.0

Figure 2. California sewage network

creases. Analysis procedures for sewage effluents are the same as the method used for domestic water except that alpha analyses are also included. The sludge samples are dried and ashed. The ashed residue is counted for alpha and beta radioactivities in a gas-flow proportional counter.

Results and discussion

Tables 1 and 2 show the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface and well water supplies in California for the calendar years 1971 and 1972. Those water supplies listed in table 1 that have a potential for becoming contaminated with radioactive material either from sewage discharges or industrial effluents are: Antioch, sewage; El Centro, industrial; Los Angelos (20 percent), industrial; Metropolitan Water District of Southern California, industrial; and San Diego, industrial. The source of water for the last four (all except Antioch) is the Colorado River.

Tables 3 and 4 present the isotopic analyses for annual composites of a number of the domestic water samples during 1971 and 1972. Essentially all the radionuclides originating from fallout were below detectable limits, except for strontium-90, which for all locations

Table 5. Gross radioactivity in California sewage samples, 1971

Sewage treatment plant	Effluent (pCi/liter)		Sludge (pCi/g dry weight)	
	Alpha	Beta	Alpha	Beta
Antioch	2	14	6	14
Bakersfield	2	22	20	13
El Centro	10	16	24	30
Eureka	1	22	3	23
Fresno	1	32	16	27
Livermore	2	11	8	46
Los Angeles City	8	17	12	46
Los Angeles County	10	36	6	18
Oakland	4	29	6	17
Orange County No. 1	8	33	14	148
Orange County No. 2	17	34	11	35
Pleasanton	6	41	109	234
Sacramento	2	16	12	22
Salinas	9	38	14	25
San Bernardino	NS	NS	NS	NS
San Diego	8	41	16	28
San Francisco:				
North Point	8	28	NS	NS
Richmond-Sunset	1	22	6	30
Southeast	8	51	8	37
San Jose	6	24	5	44
Vallejo	2	28	4	14

Table 6. Gross radioactivity in California sewage samples, 1972

Sewage treatment plant	Effluent (pCi/liter)		Sludge (pCi/g dry weight)	
	Alpha	Beta	Alpha	Beta
Antioch	3	6	4	6
Bakersfield	1	10	15	17
El Centro	7	8	22	19
Eureka	2	6	1	6
Fresno	2	23	13	14
Livermore	0	10	8	23
Los Angeles City	7	13	10	27
Los Angeles County	4	30	6	8
Oakland	1	9	6	10
Orange County No. 1	2	23	14	17
Orange County No. 2	3	18	9	6
Pleasanton	4	21	51	105
Sacramento	2	4	12	13
Salinas	9	12	12	11
San Bernardino	3	6	11	8
San Diego	5	35	13	19
San Francisco:				
North Point	3	23	NS	NS
Richmond-Sunset	0	8	4	12
Southeast	4	26	3	10
San Jose	1	2	6	5
Vallejo	0	9	7	1

was substantially below recommended ingestion limits for drinking water.

Tables 5 and 6 list the 1971 and 1972 yearly averages for alpha and beta radioactivity for sewage effluents and digested sludges. None of the plant effluents analyzed exceeded the maximum permissible concentration of alpha and beta emitting radionuclides that, in accordance with California's radiation control regulations, may be discharged into the uncontrolled environment (30 and 100 pCi/liter, respectively). One location (Pleasanton) indicated values for radioactivity in sludge samples which were consistently higher than desirable. Industries that are likely to be the principal sources of radionuclides contributed to the waste water treatment system have been advised of the Health Department's concern over the situation. A gradual reduction of radioactivity in the sludge has been apparent over the past few years, indicating that efforts toward compliance are being exercised by the waste dischargers involved.

Tables 7 and 8 show a comparison of domestic water and sewage effluent. One would expect the sewage and domestic water of a community to have essentially the same radioactivity. Where these values are not the same, the difference may be used to approximate the amount

Table 7. Comparison of gross beta radioactivity in California domestic water and sewage, 1971

Sampling station	Concentration (pCi/liter)			Ratio of sewage to water
	Water	Sewage	Difference	
Antioch	6	14	8	2.3
Berkeley-Oakland	4	29	25	7.2
El Centro	16	16	0	1.0
Eureka	6	22	16	3.7
Livermore	3	11	8	3.7
Los Angeles City	17	17	0	1.0
Pleasanton	8	41	33	5.1
Sacramento	5	16	11	3.2
San Diego	19	41	22	2.2
San Francisco, North Point	8	28	20	3.5
San Francisco, Richmond-Sunset	8	22	14	2.8
San Francisco, Southeast	8	51	43	6.4

Table 8. Comparison of gross beta radioactivity in California domestic water and sewage, 1972

Sampling station	Concentration (pCi/liter)			Ratio of sewage to water
	Water	Sewage	Difference	
Antioch	4	6	2	1.5
Berkeley-Oakland	2	9	7	4.5
El Centro	8	8	0	1.0
Eureka	6	6	0	1.0
Livermore	3	10	7	3.3
Los Angeles City	11	13	2	1.2
Pleasanton	10	21	11	2.1
Sacramento	4	4	0	1.0
San Diego	27	35	8	1.3
San Francisco, North Point	5	23	18	4.8
San Francisco, Richmond-Sunset	5	8	3	1.6
San Francisco, Southeast	5	26	21	5.2

of radioactive material entering the sewer system. Both the differences and ratio of beta concentration are shown. By evaluating both the sewage-water ratio and the difference, one can readily determine where vigilance of waste disposal practices into sewers is necessary.

REFERENCE

(1) DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analysis of environmental samples, a laboratory manual of methodology, Technical Report R59–6. Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (Revised February 1966).

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–December 1970	June 1972

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Pan American Health Organization, and the California air sampling program.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	1971	August 1973
Mexican air monitoring network	September–December 1972	June 1973
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January–December 1971	September 1973

1. Radiation Alert Network July 1973

Eastern Environmental Radiation Facility
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples 5 hours after collection, when most of the radon daughter products have decayed, and 29 hours after collection, when most of the thoron daughter products have decayed. The airborne particulate samples and precipitation samples are sent to the Eastern Environmental Radiation Facility for further analysis. All results are reported to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily measurements is available upon request from the Eastern Environmental Radiation Facility, P.O. Box 3009, Montgomery, Ala. 36109. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate and laboratory techniques during July 1973.

The Office of Radiation Programs is in the process of modifying the air program to make it more responsive to potential sources of environmental radioactivity. These changes will be reflected in future articles.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, July 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)						Precipitation		
			5-hour field estimate			Laboratory measurement			Laboratory estimate of deposition		
			Maximum	Minimum	Average [a]	Maximum	Minimum	Average [a]	Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	23	2	0	1	0.10	0.01	0.03	3	98	19.6
Alaska:	Anchorage	0									
	Attu Island	0									
	Fairbanks	6	1	0	0	<.01	<.01	<.01	0		
	Juneau	0									
	Nome	0									
	Point Barrow	0									
Ariz:	Phoenix	5	3	1	2	.07	.02	.05	0		
Ark:	Little Rock	6	2	0	1	.06	.02	.03	0		
Calif:	Berkeley	13	1	0	0	.14	<.01	.02	0		
	Los Angeles	16	2	0	1	.02	.01	.02	0		
C.Z:	Ancon	16	0	0	0	.05	.01	.02	0		
Colo:	Denver	19	4	1	3	.12	.03	.06	1	7	<.1
Conn:	Hartford	16	1	0	1	.05	<.01	.02	5	81	.8
Del:	Dover	17	1	0	0	.10	.02	.04	0		
D.C:	Washington	0									
Fla:	Jacksonville	15	1	0	0	.06	.02	.03	5	142	1.1
	Miami	6	0	0	0	.03	<.01	.01	4	90	.1
Ga:	Atlanta	13				.09	.02	.05	0		
Guam:	Agana	0									
Hawaii:	Honolulu	16	1	0	0	.07	<.01	.02	3	29	<.1
Idaho:	Boise	14	2	1	1	.06	.02	.03	0		
Ill:	Springfield	3	2	0	1	.03	<.01	.01	0		
Ind:	Indianapolis	16	2	0	1	.05	.02	.03	0		
Iowa:	Iowa City	9	3	1	2	.05	.02	.03	1	21	<.1
Kans:	Topeka	14	6	0	2	.10	.01	.05	7	139	5.0
Ky:	Frankfort	12	5	0	2	.14	<.01	.04	0		
La:	New Orleans	13	1	0	0	.08	.02	.03	3	33	3.0
Maine:	Augusta	15	1	0	0	.04	<.01	.02	0		
Md:	Baltimore	9	2	0	1	.07	.02	.03	3	30	<.1
Mass:	Lawrence	13	1	0	1	.09	.01	.03	2	80	<.1
	Winchester	12	2	0	1	.07	.02	.03	5	42	<.1
Mich:	Lansing	11	1	0	1	.03	.01	.02	6	37	3.8
Minn:	Minneapolis	13	3	0	1	.12	.02	.05	4	42	5.0
Miss:	Jackson	2	2	1	1	.05	.04	.04	0		
Mo:	Jefferson City	15	3	0	2	.08	.02	.04	4	76	<.1
Mont:	Helena	14	3	0	1	.08	.01	.03	1	4	<.1
Nebr:	Lincoln	13	6	1	4	.30	.01	.08	1	58	.1
Nev:	Las Vegas	20	2	0	1	.15	.01	.07	0		
N.H:	Concord	0									
N.J:	Trenton	16	2	0	1	.07	.02	.03	7	71	3.0
N. Mex:	Santa Fe	10	2	0	1	.11	.01	.04	0		
N.Y:	Albany	7	1	0	1	.07	.01	.03	0		
	Buffalo	19	1	0	1	.06	.01	.03	0		
	New York City	0									
N.C:	Gastonia	8	5	1	3	.50	.03	.21	2	43	12.3
N. Dak:	Bismarck	16	4	0	2	.09	<.01	<.03	1	1	<.1
Ohio:	Cincinnati	0									
	Columbus	7	2	0	1	.05	.03	.03	0		
	Painesville	15	2	0	1	.04	.01	.03	2	34	.4
Okla:	Oklahoma City	6	3	0	2	.05	<.01	.02	0		
Oreg:	Portland	21	1	0	0	.03	<.01	.01	1	1	<.1
Pa:	Harrisburg	13	3	0	1	.06	.01	.03	0		
P.R:	San Juan	13				.03	<.01	.02			
R.I:	Providence	10	1	0	0	.08	<.01	.03	0		
S.C:	Columbia	11	3	0	1	.20	.02	.10	0		
S. Dak:	Pierre	5	12	1	7	.40	.02	.20	0		
Tenn:	Nashville	11	2	0	1	.11	<.01	.05	4	53	1.8
Tex:	Austin	7	4	0	2	.03	<.01	.02	0		
	El Paso	10	2	0	1	.12	<.01	.06	0		
Utah:	Salt Lake City	19	2	1	1	.18	.02	.06	2	20	<.1
Vt:	Barre	10	3	0	1				0		
Va:	Richmond	13	2	0	0	.06	.02	.03	2	43	2.0
Wash:	Seattle	13	1	0	0	.06	<.01	.02	0		
	Spokane	8	1	0	1	.19	.02	.05	0		
W. Va:	Charleston	8	3	1	1	.06	.02	.03	2	9	.5
Wisc:	Madison	14	3	0	1	.05	.02	.03	2	33	.5
Wyo:	Cheyenne	12	5	1	3	.16	.03	.08	0		
Network summary		697	12	0	1	0.50	<0.01	0.04	83	49	1.9

[a] The monthly average is calculated by weighting the measurements of individual air samples with length of sampling period.

2. Air Surveillance Network, July 1973

National Environmental Research Center-Las Vegas[1]
Environmental Protection Agency

The Air Surveillance Network [2] (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 49 active and 73 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 2 presents the average gross beta concentrations in air for each of the network stations. The minimum reporting concentration for gross beta activity is 0.1 pCi/m³. For reporting purposes, concentrations less than 1.0 pCi/m³ are reported to 1 significant figure, and those equal to or greater than 1.0 pCi/m³ are reported to 2 significant figures. For averaging purposes, individual concentration values less than the minimum detectable concentration (~0.06 pCi/m³ for a 350-m³ sample) are set equal to the minimum detectable concentration (MDC). Reporting and rounding-off concentrations are indicated as follows:

[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

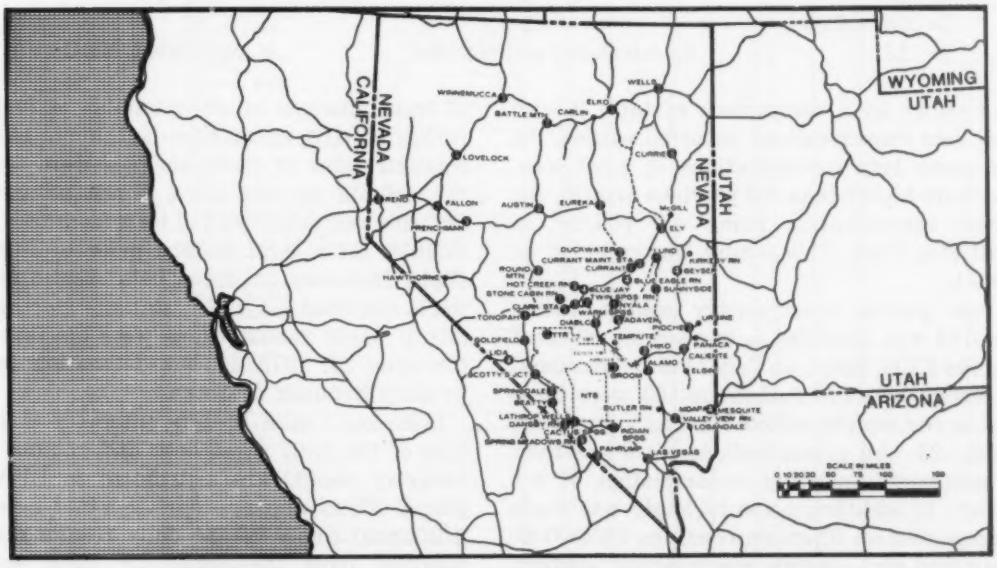

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

Concentration (pCi/m^3)	Reported value of concentration above MDC (pCi/m^3)	Reported value of concentration below MDC (pCi/m^3)
<0.05	< 0.1	< 0.1
$\geq .05$ <0.15	.1	$< .1$
$\geq .15$	As calculated and rounded	< calculated MDC

As shown by a comparison of table 2 with gross beta concentrations reported earlier, the July gross beta concentrations at most locations were higher than for previous months, the highest concentration being 4.5 pCi/m^3 at Monticello, Utah. This sample was collected on July 11.

From gamma spectrometry results, ruthenium-103 was identified in one sample collected in Idaho Falls, Idaho, on July 11 and zirconium-95, cerium-141, and ruthenium-103 were identified in one sample collected in Las Vegas, Nev. on July 23. All concentrations were less than the minimum reporting concentration of 0.1 pCi/m^3. In addition, a special study was made of composited air filters representing 120,000 m^3 of sampled air. Gamma spectroscopy analysis of the composited filters indicated the presence of trace amounts of zirconium-95, cerium-141, ruthenium-103, and barium-lanthanum-140. The concentrations of these nuclides were too low for definite quantification. Since no gamma-emitting radionuclides had been identified in air samples for several months prior to July and slight increases in gross beta concentrations were observed at most stations during the month, these radionuclides were attributed to the June 26, 1973 nuclear detonation by the People's Republic of China.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA Regional Offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 2. Summary of gross beta radioactivity concentrations in air, July 1973

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	31	1.8	0.1	0.3
	Phoenix	14	.4	<.1	.2
	Seligman	16	.4	<.1	.2
	Winslow	16	.5	<.1	.2
Ark:	Little Rock	7	.1	<.1	.1
Calif:	Baker	22	.2	<.1	.1
	Barstow	30	.3	<.1	.1
	Bishop	31	.4	<.1	.2
	Death Valley Junction	30	.6	<.1	.2
	Furnace Creek	31	.3	<.1	.2
	Lone Pine	28	.6	<.1	.2
	Needles	14	.7	<.1	.2
	Ridgecrest	31	.2	<.1	.1
	Shoshone	31	.6	<.1	.2
Colo:	Denver	17	.6	<.1	.2
	Durango	7	1.1	.1	.5
Idaho:	Boise	11	.2	<.1	.1
	Idaho Falls	11	.6	<.1	.2
	Preston	16	2.7	<.1	.4
	Twin Falls	6	<.1	<.1	.1
Iowa:	Iowa City	5	<.1	<.1	.1
	Sioux City	11	.7	<.1	.2
Kans:	Dodge City	9	.7	<.1	.2
La:	Lake Charles	10	<.1	<.1	.1
	Monroe	4	<.1	<.1	.1
	New Orleans	13	<.1	<.1	.1
Minn:	Minneapolis	8	.2	<.1	.1
Mo:	Clayton	10	.1	<.1	.1
	Joplin	16	.7	<.1	.1
Nebr:	North Platte	15	1.0	<.1	.3
Nev:	Alamo	31	.6	<.1	.2
	Austin	14	.2	<.1	.1
	Battle Mountain	15	.9	<.1	.3
	Beatty	31	.4	<.1	.2
	Blue Eagle Ranch (Currant)	31	1.0	<.1	.2
	Blue Jay	31	.4	<.1	.1
	Caliente	31	.5	<.1	.2
	Currant Ranch	31	.6	<.1	.2
	Diablo	31	.8	<.1	.2
	Duckwater	27	.8	<.1	.2
	Elko	16	.5	<.1	.2
	Ely	31	.3	<.1	.1
	Eureka	31	.6	<.1	.2
	Fallini's Twin Springs Ranch	31	.7	<.1	.2
	Fallon	15	.3	<.1	.2
	Frenchman Station	18	1.0	<.1	.2
	Geyser Maintenance Station	2	<.1	<.1	.1
	Goldfield	31	.5	<.1	.2
	Groom Lake	14	.5	<.1	.2
	Hiko	31	.6	<.1	.2
	Indian Springs	31	.4	<.1	.2
	Las Vegas	20	.8	<.1	.2
	Lathrop Wells	31	.3	<.1	.1
	Lida	20	.3	<.1	.2
	Lovelock	3	<.1	<.1	.1
	Lund	29	.8	<.1	.2
	Mesquite	29	.5	<.1	.2
	Nyala	30	1.9	<.1	.2
	Pahrump	19	.2	<.1	.1
	Pioche	16	.4	<.1	.1
	Reno	13	.1	<.1	.1
	Round Mountain	31	.9	<.1	.2
	Scotty's Junction	31	.8	<.1	.2
	Stone Cabin Ranch	31	.8	<.1	.1
	Sunnyside	30	1.4	<.1	.2
	Tonopah	31	.6	<.1	.2
	Tonopah Test Range	17	.6	<.1	.2
	Warm Springs	30	.9	<.1	.2
	Warm Springs Ranch	31	.5	<.1	.2
	Wells	15	.6	<.1	.2
	Winnemucca	15	.8	<.1	.2
N. Mex:	Albuquerque	9	1.0	<.1	.2
	Carlsbad	13	.5	<.1	.1
Okla:	Muskogee	15	.8	<.1	.1
Oreg:	Burns	15	.2	<.1	.1
	Medford	6	.1	<.1	.1
S. Dak:	Aberdeen	11	.8	<.1	.3
	Rapid City	15	1.0	<.1	.3
Tex:	Abilene	15	.2	<.1	.1
	Amarillo	15	.6	<.1	.2
	Austin	7	<.1	<.1	.1
	Forth Worth	14	.5	<.1	.1
Utah:	Cedar City	27	1.2	<.1	.2
	Delta	30	1.0	<.1	.2
	Dugway	6	.1	<.1	.1
	Enterprise	16	1.3	<.1	.4
	Garrison	31	.8	<.1	.2

See footnotes at end of table.

Table 2.—Summary of gross beta radioactivity concentrations in air, July 1973—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Utah:	Logan	15	1.3	<.1	.4
	Milford	30	1.3	<.1	.2
	Monticello	15	4.5	<.1	.4
	Parowan	16	1.3	<.1	.3
	Provo	16	1.3	<.1	.3
	Roosevelt	15	1.3	<.1	.2
	Salt Lake City	12	.8	<.1	.2
	St. George	31	1.0	<.1	.2
	Wendover	16	1.6	<.1	.3
Wash:	Seattle	15	<.1	<.1	.1
	Spokane	9	<.1	<.1	.1
Wyo:	Rock Springs	15	1.6	<.1	.4
	Worland	15	1.6	<.1	.2

3. Canadian Air and Precipitation Monitoring Program,[3] July 1973

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and

[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

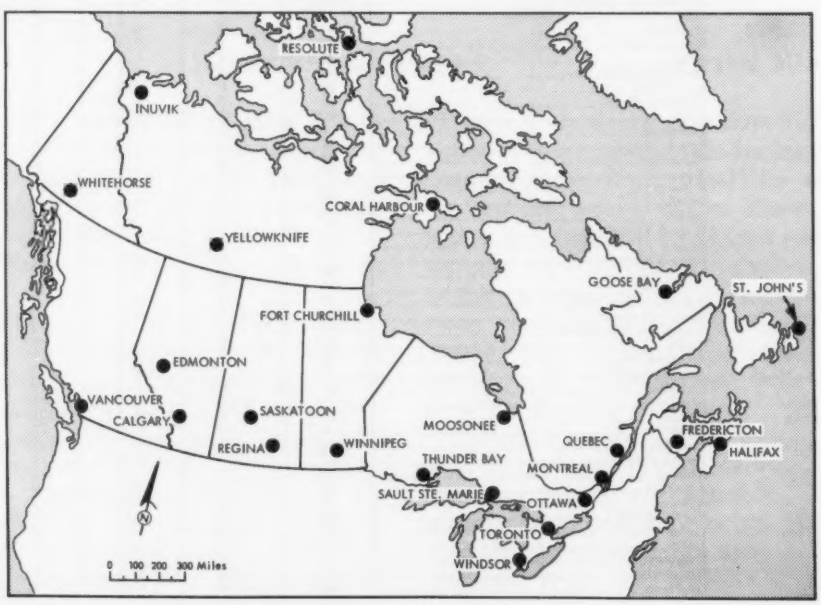

Figure 4. Canadian air precipitation monitoring area

methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for July 1973 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, July 1973

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	11	0.09	0.01	0.05	4	0.2
Coral Harbour	15	.05	<.01	.03	6	.9
Edmonton	10	.07	.01	.04	8	.1
Ft. Churchill	12	.02	<.01	.01	6	.6
Fredericton	13	.05	<.01	.03	11	.7
Goose Bay	14	.02	<.01	.02	4	.5
Halifax	15	.06	<.01	.03	4	.7
Inuvik	12	.04	<.01	.02	10	.4
Montreal	18	.04	<.01	.02	12	.9
Moosonee	11	.04	<.01	.02	1	.1
Ottawa	16	.11	<.01	.06	8	.3
Quebec	16	.04	<.01	.02	6	1.3
Regina	16	.04	<.01	.02	6	.3
Resolute	11	.03	<.01	.02	24	.5
St. John's, Nfld.	12	.04	<.01	.02	9	.6
Saskatoon	11	.04	<.01	.02	12	.5
Sault Ste. Marie	19	.05	<.01	.03	10	1.1
Thunder Bay	15	.04	<.01	.02	12	1.9
Toronto	7	.03	<.01	.02	2	.1
Vancouver	9	.05	<.01	.03	96	.9
Whitehorse	11	<.01	<.01	<.01	8	.2
Windsor	8	.03	.01	.02	2	.2
Winnipeg	16	.06	.01	.04	12	1.4
Yellowknife	13	.04	<.01	.02	34	.9
Network summary	311	0.11	<0.01	0.03	13	0.6

4. Pan American Air Sampling Program July 1973

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The July 1973 air monitoring results from the participating countries are given in table 4.

Figure 5. Pan American air sampling program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, July 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	20	11.90	0.00	0.94
Chile:	Santiago	31	.05	.00	.02
Colombia:	Bogota	21	.05	.00	.01
Ecuador:	Cuenca	17	.01	.00	.00
	Guayaquil	17	.03	.00	.01
	Quito	0			
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	26	.03	.00	.01
Venezuela:	Caracas	11	.03	.00	.02
West Indies:	Trinidad	10	.15	.03	.07
Pan American summary		153	11.90	0.00	0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging 0.00 pCi/m³.

5. California Air Sampling Program July 1973

Radiologic Health Section
California State Department of Health

The Radiologic Health Section of the California State Department of Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micrometer pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the gross beta radioactivity in air for July 1973. The gamma results are presented quarterly.

Figure 6. California air sampling program stations

Table 5. Gross beta radioactivity in California air July 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	31	0.66	0.07	0.17
Barstow	31	.47	.03	.19
Berkeley	31	.17	.00	.04
El Centro	20	.39	.09	.21
Eureka	31	.12	.00	.03
Fresno	31	.46	.08	.16
Los Angeles	28	.12	.00	.05
Redding	29	.39	.05	.14
Sacramento	31	.53	.01	.10
Salinas	31	1.93	.02	.18
San Bernardino	31	.37	.04	.13
San Diego	31	.13	.02	.06
San Luis Obispo	31	.19	.00	.07
Santa Rosa	31	.17	.00	.07
Summary	418	1.93	0.00	0.11

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

A summary of the environmental radioactivity data follows for the Los Alamos Scientific Laboratory.

[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Los Alamos Scientific Laboratory[2] Calendar Year 1971

University of California
Los Alamos, N. Mex.

The Los Alamos Scientific Laboratory, which is administered by the University of California for the U.S. Atomic Energy Commission (AEC), lies mostly in Los Alamos County, with only a small segment in Santa Fe County, and encompasses approximately 28,000 acres. This parcel of AEC controlled land contains all of the laboratory technical areas (figure 1).

The laboratory and community at Los Alamos are located on the Pajarito Plateau, situated west of the Rio Grande on the eastern slopes of the Jemez Mountains in north-central New Mexico. This location was originally chosen for its relative isolation. Thus the area surrounding Los Alamos, including all of Los Alamos County and large portions of Sandoval and Santa Fe Counties, is largely undeveloped except for those areas occupied by the laboratory facilities and the associated communities of Los Alamos and White Rock. Large tracts of land in the Jemez Mountains to the north, west, and south of the laboratory site are held by the Forest Service. This land is largely covered by fir and aspen forests which support the usual variety of western mountain wildlife. Agriculture is limited to home gardens with some grazing of beef cattle. In river valleys to the east, agriculture is restricted to relatively small plots supported by irrigation. Primary crops are chili peppers, beans, and tree fruits. Milk is not produced in commercial quantities in the immediate vicinity of Los Alamos. The technical areas are principally located on the mesa

[2] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites —Calendar Year 1971."

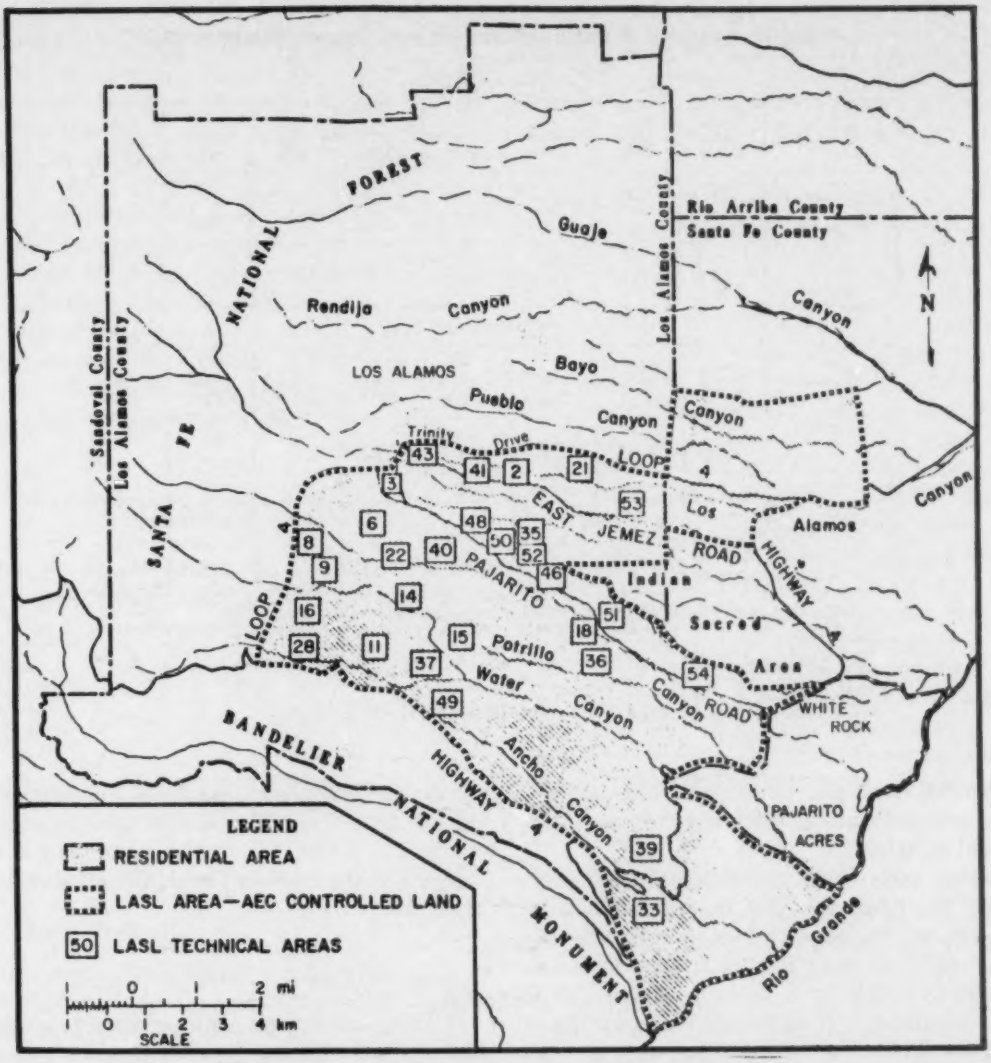

Figure 1. Los Alamos county and LASL technical areas

tops with the interspersed canyons serving as separation areas, although a few have been located at the bottoms of steep, narrow canyons for isolation and safety purposes.

Gaseous effluents

Since the laboratory is a large, broadly diversified organization employing a few thousand personnel engaged in fundamental and applied research in the natural sciences with emphasis on nuclear materials, the facilities include literally hundreds of potential sources of airborne material. At present, processes which are known to have the potential for significant releases are controlled and monitored, but numerous laboratory hoods still exist where procedural controls are relied upon for proper utilization. However, it should be stressed that within this continually changing environment of research, the major potential sources of troublesome materials are confined to a few

Table 1. Summary of major airborne effluents, January-December 1971

January-June 1971

Technical area	Gross beta (μCi)	^{238}Pu, ^{239}Pu (μCi)	^{235}U (μCi)	U[a] (μCi)	^{131}I (μCi)	^{137}Cs (μCi)	^{41}Ar (Ci)	^{3}H (Ci)
3	600	5,900			6,100			5
21		970	350					2
2						560	710	
33								3,000
41								260
35								2,700
Other	900	40	90	180				

July-December 1971

Technical area	Gross beta (μCi)	^{238}Pu, ^{239}Pu (μCi)	^{235}U (μCi)	U[a] (μCi)	^{131}I (μCi)	^{88}Rb, ^{138}Cs (mCi)	^{41}Ar (Ci)	^{3}H (Ci)
2						26	860	
3	880	3,000	370	210	850			84
21		570	830					3
33								1,100
35		4						430
41		5						60
46			4					
48	990	14						
50	51	5						
Other				[b] 890				1,100

[a] Natural and depleted uranium. Does not include those amounts listed under uranium-235.
[b] Kilograms of depleted uranium. Mass spectrometer analysis of a typical sample indicates the composition to be (weight percent):
Uranium-234, 0.0006 percent
Uranium-235, .1925 percent
Uranium-236, .0036 percent
Uranium-238, 99.803 percent
An estimate of the uranium activity only (excluding daughters) for 890 kg is 0.33 Ci.

well-known locations. The major sources of airborne contaminants at the laboratory are summarized in table 1.

Certain tests with conventional explosives involve the dispersal into the atmosphere of kilogram quantities of depleted uranium and occasional small quantities of tritium and nonradioactive metals such as lead, copper, beryllium, aluminum, and cadmium. The amounts of materials given for these tests are not the amounts actually dispersed into the atmosphere; significant fractions remain in the immediate vicinity of the test site. The magnitudes of these fractions will be studied later.

The increase in rubidium-88 and cesium-138 from the TA–2 reactor site in July–December 1971 over that reported in January–June was almost entirely due to a single release in December when a valve in the stack discharge line failed. To document the environmental consequences of this release, filters from selected downwind weekly air samplers were collected and analyzed. No activity attributable to this release was found on any of the weekly filters or on the filter from the daily air sampler collected that day. The excess tritium released from TA–3 was due to the rupture of several targets at the tandem Van de Graaff accelerator facility.

Liquid effluents

Cooling water and sanitary sewage comprise the majority of the liquid effluent streams at the laboratory. Again, processes which are known to have the potential for significant releases are controlled and monitored, but numerous drains exist where procedural controls are relied upon for proper utilization.

The effluents are released into canyons that contain intermittent streams. The effluents recharge water in the alluvium that is depleted by evaporation or transpiration and do not reach the Rio Grande. None of the effluent streams recharge aquifers from which municipal, industrial, or irrigation water is drawn.

The primary sources of potentially contaminated liquid effluent from laboratory operations

are from the industrial liquid waste treatment plant at TA–21 and from the central industrial liquid waste treatment plant at TA–50. Effluents from the TA–21 plant are released into DP canyon that is tributary to Los Alamos Canyon, and those effluents from TA–50 are released into Effluent Canyon, which is tributary to Mortandad Canyon. Water is released with concentrations lower than those listed in table 2, AEC Manual Chapter 0524, but evaporation and adsorption tends to concentrate the contamination in the channel alluvium. The amounts of radionuclides released from these two sources are shown in table 2.

Table 2. Summary of major liquid effluents January-December 1971

Contaminant	January-June 1971		July-December 1971	
	TA-21 (mCi)	TA–50 (mCi)	TA-21 (mCi)	TA–50 (mCi)
Gross alpha	[a] 0.43	5.85	[b] 0.28	5.0
Gross beta		768.51		320
Plutonium-238	[a] .43	3.81	.10	2.6
Plutonium-239			.18	.47
Strontium-89	[c]	[c] 28.02	4.6	.08
Strontium-90			12	.11

[a] All alpha activity assumed to be due to plutonium.
[b] All alpha activity is assumed to be due to plutonium, although as much as 10 percent may be due to americium-241 for individual discharges.
[c] Several spot analyses indicated a ratio of 52:48 for strontium-89: strontium-90.

Solid waste disposal

Solid wastes, consisting mostly of contaminated sludges from the industrial waste treatment plants and potentially contaminated trash from routine laboratory operations, are buried in pits at TA–54 on the Mesita del Buey (a location chosen in cooperation with the U.S. Geological Survey to assure long time localization of radioactive materials) and in lined disposal shafts at TA–21. When appropriate, wastes are stabilized in concrete or other material prior to or during burial. The quantities of materials placed in storage during this period are given in table 3.

The quantity of radioactive material in the laboratory trash and equipment is not estimated because it is below the limits of detection for any device for the measurement of gross activity; however, it should be relatively low compared to that in the sludge. In addition, one batch of waste containing about 9 grams of plutonium was placed in a shaft at the burial site and embedded in concrete.

Routine monitoring programs

Several routine monitoring programs are carried out to provide information on the potential radiation doses to people in the environs and on the possible accumulations of radioactive or nonradioactive materials. The results of these programs are relayed immediately to the responsible operations so that any undesirable conditions may be immediately corrected.

Station locations are chosen to provide the geographic coverage desired for each type of measurement, with constraints imposed by physical accessibility and by availability of power. Similarly, collection dates are chosen to give a sampling frequency adequate for each type of measurement, with accessibility and distance from the laboratory being the major constraining factors. Those stations which are within the laboratory boundaries are listed in the tables as "onsite", and those which are outside of these boundaries are designated as "offsite."

Air monitoring

The air monitoring program is designed to provide for general surveillance of the levels of gross alpha and beta radioactivity in air, the concentrations of those specific radionuclides directly associated with laboratory operations and the concentrations of certain nonradioactive materials.

A high volume air sampler drawing air through an MSA Type BM2133 filter cartridge and a charcoal canister at the rate of approximately 400 liters per minute was maintained on the roof of the Occupational Health Laboratory (TA–3). A second charcoal canister was operated on a similar high volume sampler at the waste treatment facility (TA–50) during January–June 1971. The filter and the canister were changed daily. The particulate material on the filters is measured for gross beta emission twice, immediately and 8 days after collection, on an alpha-beta gas-flow proportional

Table 3. Summary of solid waste disposal, January-December 1971

Burial site	Nature of waste	Container or stabilizer	Estimated volume (liters)	Estimated activity (Ci)
January-June 1971:				
TA-54	^{239}Pu sludge from TA-50	55 gallon steel barrels	84,800	2.6
TA-54	^{3}H	Metal containers filled with asphalt	80	6,400
TA-54	Trash		1,260,000	Trace
TA-54	Equipment		885,000	Trace
TA-54	Fission products and activated metal	Disposal shafts	134	120
TA-21	^{239}Pu sludge from TA-21	201,690 liters cement paste in lined disposal shafts	117,020	156
TA-21	Fission products			.4
July-December 1971:				
TA-54	Classified	Steel drums, 30 and 55 gallons	71,000	Not estimated
TA-54	Hot cell wastes, activated metal, wastes containing fission products	Metal containers	175	120
TA-54	Contaminated sludge from TA-50 liquid waste treatment plant	Steel drums, 55 gallons	42,000	1.9
TA-54	Air exhaust filters	Wooden boxes	18,100	.6
TA-54	Laboratory trash and scrap	Bags, boxes, crates, drums	2,300,000	Not estimated
TA-54	Wastes containing ^{239}Pu	Steel drums, 55 gallons	42,000	180
TA-21	Contaminated sludge from TA-21 liquid waste treatment plant	Cement paste	25,000	180

counter. The activity collected by the canister is measured by gamma ray spectrometry with emphasis on the iodine-131 determination. The initial measurement of the gross beta is taken to give early warning of large changes which would be apparent above the natural radon-thoron background fluctuations. The primary record of the activity is established by the 8-day measurement. The results in general are comparable with those samplers operated elsewhere in the country by the Environmental Protection Agency (EPA).

The main air monitoring network consists of an array of air sampling stations whose samples are collected weekly. During the period covered by this report, several new stations were added and several were deleted from the past network expanding the total number in operation from 23 in January to 35 in December. The locations of these stations as of the end of the period are given in figure 2. Each station consists of a pump which pulls air through a 50 mm membrane filter with a pore size of 1.2 μm and, at 12 stations, a charcoal cartridge for iodine collection at a rate of about 55 liters/min. In July, the filter was changed to a 78-mm Microsorban filter having an efficiency of about 99.8 percent for 0.3 μm di-octylphthalate (DOP) particles (a standard test aerosol for determining filter efficiency) and an 80-mm Welsh charcoal respirator cartridge at a flow rate averaging about 75 liters/min. These filters were measured for gross alpha and gross beta emitters on a gas-flow proportional counter, 1 day after collection and 8 days after collection. The filters from each station are then pooled to form a monthly composite sample which is analyzed radiochemically for plutonium and fluorometrically for uranium. An alpha spectrometer is used to allow resolution of plutonium-238 and plutonium-239. The charcoal cartridges are collected weekly and analyzed for iodine on a gamma ray spectrometer. In addition, the stations collect a separate weekly sample by drawing air through a tube of silica gel desiccate at an average flow of about 50 ml/min. This arrangement permits water vapor collection at about 95-percent efficiency. Water samples are obtained by heating the desiccate and condensing the resulting vapor. A standard aliquot of this water is measured for tritium content by liquid scintillation counting. This measurement is combined with the average humidity for the week to obtain an estimate of the average tritium concentration in air.

The gross alpha and gross beta activities are measured primarily for the purpose of screening the samples to insure against unexpectedly high concentrations of radionuclides which are not covered by the more specific analyses. A summary of the results of the measurements taken after 8 days decay is given in table 4 for January–December 1971.

The gross alpha measurements have been corrected both for background of the counting chamber and for the approximately 0.1 percent

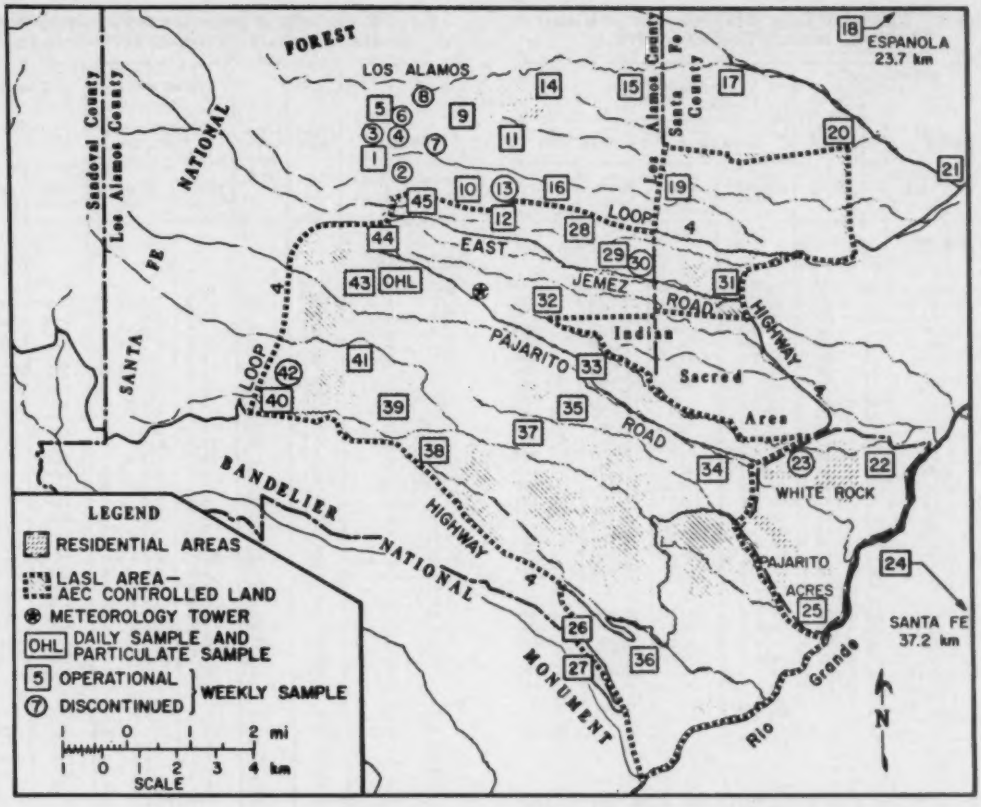

Figure 2. Locations of atmospheric monitoring stations, Los Alamos

of the beta counts that feed into the alpha channel of the counter ("cross-talk"). Due to erratic behavior of the counter during January–June, a detection limit could not be derived from considerations of the analytical procedure and the counting system. Instead, statistical analyses of the analytical results were used to estimate this detection limit. The entire group of samples (all stations and all times) were used to derive the detection limit for individual samples (maximum column), and only activities which lie more than 2.326 standard deviations above the mean (99-percent confidence level) were considered to be detectable. This procedure led to the value of 5 fCi/m³ given in the table. A similar procedure, but considering the number of samples collected at each station, was used to arrive at the estimate of 2 fCi/m³ for the detection limit for station averages. During July–December, the background was determined to be 0.2 counts per minute. A filter from the sampling array can thus be distinguished from the blank if it contains a total activity of more than 0.3 counts/min. Consideration of total flow through the filter yields a minimum detectable level of about 0.2 fCi/m³ for the total collection and analysis procedure. This value is subject to variation due to fluctuations in sampling rate.

The gross alpha and beta emitters varied with time as expected from the seasonal variation of fallout with no real difference between the stations indicating that the activity was, within the error of the measurement, due to long term fallout from past weapons tests.

A summary of the results of the plutonium analyses performed on the monthly composites of the weekly air filters is given in table 5. The

Table 4. Results of gross measurements on weekly air filters, January-December 1971

Station	Number of samples	Concentration (fCi/m³)			
		Gross alpha		Gross beta	
		Maximum	Average	Maximum	Average
January-June 1971					
Offsite:					
2	11	<5	<2	1,100	520
3	23	<5	<2	1,800	610
4	22	<5	<2	1,400	510
5	23	<5	<2	2,100	640
6	22	5.5	<2	1,700	570
7	23	<5	<2	2,300	620
8	11	<5	<2	1,700	810
9	22	<5	<2	1,600	550
10	18	<5	<2	2,200	560
11	23	<5	<2	2,100	660
13	23	<5	<2	2,100	610
14	23	6.7	<2	1,300	580
15	23	7.5	<2	2,100	760
16	22	<5	<2	1,400	570
17	23	5.0	<2	1,400	570
18	11	8.3	<2	1,800	100
20	21	<5	<2	1,500	500
21	21	<5	<2	1,000	330
23	23	<5	<2	1,900	680
24	11	12	<2	1,400	870
25	12	5.5	<2	2,000	1,030
Onsite:					
30	22	7.4	<2	1,000	480
36	22	<5	<2	1,900	680
38	23	<5	<2	1,900	580
42	22	<5	<2	1,000	470
44	22	<5	<2	2,400	780
45	23	<5	<2	1,800	610
Detection limit:		See text		10	

Table 4. Results of gross measurements on weekly air filters, January-December 1971—continued

Station	Status[a]	Number of samples	Gross alpha		Gross beta	
			Concentration (fCi/m³)		Concentration (fCi/m³)	
			Maximum	Average	Maximum	Average[b]
July-December 1971						
Offsite:						
1	N	24	7.3	1.3±0.7	400	130± 40
2	D	2	1.4	1.0±5.0	140	120±200
3	D	13	7.0	1.4±1.1	360	190± 60
4	D	2	1.7	1.2±6.2	300	240±780
5	N	14	1.2	.6± .2	230	100± 30
6	D	2	1.7	1.6±1.9	310	310± 10
7	D	2	2.1	1.7±4.9	380	300±100
8	D	13	5.0	1.3± .8	420	220± 80
9	N	24	5.2	1.0± .5	410	130± 40
10	C	27	9.4	1.1± .7	370	140± 40
11	C	27	5.2	1.1± .4	360	140± 40
12	C	27	10	1.1± .7	400	140± 40
13	D	2	2.3	1.9±5.6	360	340±340
14	C	27	3.5	1.1± .3	450	140± 40
15	C	27	8.5	1.2± .6	440	170± 50
16	C	27	9.1	1.2± .7	400	140± 40
17	C	27	5.5	1.1± .4	410	150± 40
18	C	27	6.9	1.4± .5	550	170± 50
19	N	16	31	2.6±4.0	220	90± 20
20	C	27	5.7	1.1± .4	390	150± 40
21	C	27	1.9	.7± .2	270	100± 20
22	N	14	2.0	.7± .3	230	110± 30
23	D	13	5.9	1.5± .9	430	200± 70
24	C	<25	4.0	1.6± .4	350	160± 40
25	C	27	6.0	1.1± .5	400	150± 50
26	N	8	0.9	.3± .2	220	90± 50
27	N	8	2.9	.6± .8	240	90± 50
Onsite:						
28	N	17	1.5	.5± .2	210	70± 20
29	N	9	14	2.1±3.5	220	100± 50
30	D	10	5.4	1.6±1.1	440	170±100
31	N	17	1.1	.5± .2	220	90± 20
32	N	8	1.0	.3± .3	360	120±100
33	N	17	2.0	.7± .3	180	90± 20
34	N	17	1.4	.5± .2	120	70± 10
35	N	18	2.3	.8± .3	220	80± 20
36	C	27	3.2	.8± .3	390	120± 40
37	N	16	1.5	.6± .3	220	100± 20
38	C	27	5.2	1.1± .5	430	160± 50
39	N	16	5.1	1.0± .7	230	100± 20
40	N	15	2.1	.8± .4	260	100± 30
41	N	16	1.4	.5± .2	220	90± 20
42	D	12	3.4	1.3± .6	330	210± 70
43	N	8	.9	.4± .3	250	100± 50
44	C	27	11	1.7± .9	440	160± 40
45	C	27	8.1	1.1± .6	290	130± 30

[a] Status: N, new station initiated this report period; D, old station discontinued this report period; and C, old station continuing in operation.
[b] Average and 95-percent confidence limits for the average.
[c] Includes two 2-week samples.

average values are generally in line with the concentrations of plutonium-239 reported by the Environmental Protection Agency as occurring from worldwide fallout. For example, reported values for Denver are 55 aCi/m³ and 125 aCi/m³ for the first and second 3-month periods of 1971, respectively (*1, 2*). In view of this correspondence and the lack of difference between the individual sampling stations, it is concluded that plutonium-239 concentrations listed are primarily due to fallout with no detectable contribution from the laboratory.

The only significant station effect in the plutonium-239 concentrations occurred at station 44 (Administration Building). Because the plutonium-238 concentration also was high at this station, both high measurements are attributed to the CMR building airborne effluents. All other plutonium-239 concentrations fall within the range of values attributable to worldwide fallout (*1*) and exhibit the same increase or decrease with time as did the gross alpha and gross beta concentrations.

All future plutonium effluents will be decreased. Measures are underway to improve the filtration of the exhaust from the CMR building. This work should reduce the effluents by several orders of magnitude and is expected to be completed by mid 1973. A new and improved plutonium processing facility to replace the one at TA–21 is in the conceptual design stage.

Analysis of the charcoal cartridges indicated that iodine-131 could not have been present at

Table 5. Plutonium concentrations in air January-December 1971

Station	Number of samples	Concentration (aCi/m³)			
		Plutonium-239		Plutonium-238	
		Maximum	Average	Maximum	Average
January-June 1971					
Offsite:					
2	5	130	85	1,100	280
3	6	140	79	47	16
4	6	150	81	26	16
6	6	130	84	35	14
7	6	160	98	48	31
8	6	170	92	18	13
9	3	360	180	88	60
10	6	150	100	210	48
11	5	160	96	95	34
12	6	150	100	35	17
13	6	160	97	53	20
14	6	130	69	31	20
15	6	150	94	70	30
16	6	140	89	22	12
17	6	160	88	61	23
18	3	180	140	22	20
20	6	98	67	35	18
21	6	160	64	39	18
23	6	160	91	44	19
24	3	170	120	7	5
25	3	130	120	32	15
Onsite:					
30	6	130	69	35	19
36	6	160	100	31	17
37	6	130	95	74	30
42	6	140	87	22	12
44	6	280	190	280	130
45	6	150	96	93	48
Detection limit		10		10	

Table 5. Plutonium concentrations in air January-December 1971—continued

Station	Status[a]	Number of samples	Concentration (aCi/m³)			
			Plutonium-239		Plutonium-238	
			Maximum	Average	Maximum	Average
July-December 1971						
Offsite:						
1	N	6	55	30 ± 20	10	5 ± 3
3	D	3	70	48 ± 47	40	23 ± 36
5	N	4	25	15 ± 12	13	6 ± 8
8	D	1	15	—	35	—
9	N	6	80	37 ± 27	25	12 ± 8
10	C	7	65	42 ± 16	55	25 ± 18
11	C	7	40	21 ± 14	45	18 ± 16
12	C	7	45	28 ± 11	85	29 ± 27
14	C	7	80	41 ± 18	30	13 ± 19
15	C	7	65	37 ± 19	40	18 ± 12
16	C	7	65	35 ± 13	40	15 ± 13
17	C	7	55	30 ± 19	15	7 ± 4
18	C	7	32	20 ± 9	32	10 ± 9
19	N	5	200	[c]23 ± 36	5,900	[c]26 ± 58
20	C	7	90	40 ± 25	45	15 ± 15
21	C	7	36	24 ± 09	55	17 ± 17
22	N	4	32	25 ± 12	23	11 ± 14
23	D	3	45	30 ± 37	20	12 ± 20
24	C	7	60	40 ± 10	40	13 ± 12
25	C	7	100	37 ± 27	27	14 ± 9
26	N	3	26	21 ± 23	51	19 ± 68
27	N	3	48	32 ± 35	24	13 ± 26
Onsite:						
28	N	5	28	18 ± 12	19	11 ± 8
29	N	3	130	57 ± 150	19	9 ± 22
30	D	2	40	28 ± 160	20	13 ± 95
31	N	5	46	28 ± 18	25	12 ± 11
32	N	3	43	25 ± 40	25	14 ± 26
33	N	5	29	21 ± 11	34	17 ± 16
34	N	5	55	18 ± 26	30	11 ± 14
35	N	5	24	17 ± 7	20	10 ± 8
36	C	7	75	33 ± 23	38	16 ± 12
37	N	5	40	31 ± 13	20	11 ± 8
38	C	7	50	26 ± 14	25	16 ± 8
39	N	5	95	39 ± 47	15	8 ± 6
40	N	4	33	23 ± 16	24	10 ± 15
41	N	5	120	39 ± 58	15	8 ± 7
42	D	3	55	27 ± 61	20	10 ± 22
43	N	3	34	29 ± 12	20	12 ± 20
44	C	7	330	170 ± 100	140	65 ± 52
45	C	7	180	45 ± 58	100	32 ± 32

[a] Status: N, new station initiated this report period; D, old station discontinued this report period; and C, old station continuing in operation.
[b] Average and 95-percent confidence limits for the average.
[c] Average and confidence interval do not include the high value.

concentrations above 10 fCi/m³, the estimated MDL of the system.

Stations to the north and east of the locations where plutonium-238 releases occurred (TA–2 and the Chemistry and Metallurgy Research Building in TA–3) exhibited concentrations generally higher than the average of all other stations to the south and the distant stations in Santa Fe and Espanola. This result again is consistent with the wind patterns in Los Alamos over the 6-month period.

The maximum observed onsite plutonium-238 concentration, 280 aCi/m³ at station 44 (Administration Building), was only 14 percent of 2 pCi/m³ concentration guide value for the soluble form of the isotope as given in AEC Manual Chapter 0524 for occupational exposure. Public traffic on adjacent roads is normally permitted, and the boundary of the laboratory is near this station. A comparison to the 70 fCi/m³ concentration guide for an individual in the general public indicates that the maximum concentration is less than 0.4 percent of this guide. During January–June, only station 9 showed a concentration significantly higher than the average. This concentration, 88 aCi/m³, was only 0.1 percent of the AEC standard. The maximum offsite concentration, 85 aCi/m³ at station 12 (Museum), was approximately 0.1 percent of this same guide value. An unusually high concentration (1.1 fCi/m³) occurred at station 2 in the town of Los Alamos. It was an order of magnitude higher than all other monthly samples, and no explanation can be given for it. The unusually high concentration of 5.9 fCi/m³ recorded at station (Bayo Canyon Sewage Treatment Plant) during July–December, is nearly two orders of magnitude higher than all other measurements made during the 12-month

period and is not completely understood. It appears that one of these anomalously high values occurs about every 6 months at one of the weekly air sampling stations.

The measurements of tritiated water vapor in air are summarized in table 6. Analysis of the data indicates that there were significant differences between sampling stations. The onsite sampling stations, located closer to the areas where tritium releases occurred, indicated atmospheric concentrations higher than those measured by the samplers in the surrounding county, and these, in turn, showed levels above those in Santa Fe and Espanola. If the levels in Santa Fe and Espanola can be considered to be representative of the background tritium concentrations due to worldwide fallout, then the concentrations in the communities in Los Alamos County appear to be about twice background, and the concentrations at some of the onsite locations are about 10 times background. The average offsite concentrations, including background, in the Los Alamos area are about 0.08 percent of the concentration guide of 0.2 nCi/liter as given in AEC Manual Chapter 0524 for individuals in the population or about 0.2 percent of the recommended guide for population groups. The average concentrations at the onsite stations are about 0.01 percent of the recommended guide for controlled areas (5 nCi/liter).

Precipitation monitoring

Deposition is measured on a daily basis using a precipitation collector 0.4 m^2 in area located at the waste treatment plant (TA–50). The collector is rinsed with water and the rinse water is combined with whatever precipitation may have been collected. The sample is filtered, the water is evaporated to dryness and the filter is

Table 6. Summary results for tritium analyses of weekly air samples, January-December 1971

Station	Number of samples	Concentration (pCi/m³)		Station	Status[a]	Number of samples	Concentration (pCi/m³)	
		Maximum	Average				Maximum	Average[b]
January-June 1971				July-December 1971				
Offsite:				Offsite:				
1	20	420	100	1	N	23	110	34 ± 10
11	20	450	160	5	N	13	80	26 ± 11
15	20	200	70	9	N	23	82	37 ± 9
16	20	400	140	10	N	21	83	37 ± 9
18	11	140	50	11	C	27	190	50 ± 18
21	20	600	110	12	C	27	240	74 ± 21
23	20	240	110	14	N	22	400	59 ± 40
24	11	140	60	15	C	27	110	33 ± 8
				16	C	27	740	120 ± 60
Onsite:				17	N	19	67	22 ± 6
36	20	3,400	750	18	C	27	100	33 ± 10
38	20	2,200	220	19	N	16	200	36 ± 25
44	20	1,600	330	20	N	19	94	27 ± 10
11	20	2,200	630	21	C	27	150	43 ± 13
Detection level		20		22	N	14	55	20 ± 6
				23	D	13	140	76 ± 24
				24	C	27	80	31 ± 7
				25	N	14	220	32 ± 31
				26	N	8	53	30 ± 12
				27	N	8	89	30 ± 25
				Onsite:				
				28	N	17	320	85 ± 47
				29	N	8	460	79 ±130
				31	N	17	930	98 ±110
				32	N	8	140	62 ± 39
				33	N	17	310	59 ± 39
				34	N	17	300	54 ± 37
				35	N	18	120	38 ± 16
				36	C	27	1,800	240 ±140
				37	N	16	760	82 ± 99
				38	C	27	920	74 ± 67
				39	N	16	190	42 ± 23
				40	N	15	33	19 ± 4
				41	N	16	100	45 ± 14
				43	N	8	73	36 ± 21
				44	C	27	230	76 ± 21
				45	N	21	120	43 ± 13

[a] Status—N, new station or old station fitted with moisture collector this report period; D, old station discontinued this report period; C, old station continuing in operation.
[b] Average and 95 percent confidence limits for the average.

wet ashed. The two resulting planchets are measured separately on the Widebeta counter for gross beta activity, and the total beta activity is obtained arithmetically. Again measurements are taken immediately and after 8 days with the 8-day measurement considered to represent the gross emitters free of the interfering daughters of radon and thoron. Again, an increase in the earlier spring and a decrease in the fall and winter was noted although this trend is considerably obscured by fluctuations due to scavenging by natural precipitation.

External radiation monitoring program

A thermoluminescent dosimeter (TLD) array is maintained to monitor gamma and x radiation at natural background levels to provide information on any possible contribution due to laboratory activities. To improve the quality of the data from this array, substantial changes in equipment, location, and procedure were affected this reporting period.

During the first half of the year, the array used two TLD's at each station. One was the EG&G Model TL–2B consisting of a CaF_2:Mn powder chemically bonded to a heating coil and enclosed in an evacuated glass envelope; the other was the MBLE consisting of CaF_2:(unknown activator) bonded to a heating cylinder and enclosed in an evacuated glass envelope. Two sets of each were maintained and swapped for reading at approximately 30-day intervals. A summary of the results is given in table 7. Both types suffered from an inherent natural dosimeter background, presumably due to naturally occurring radioisotopes in the binder and glass envelope. This source normally contributed 3 to 5 times the external dose intended to be measured and made interpretation and evaluation of the measurements very difficult. In addition, unexplainable discrepancies in readings from the two dosimeters at each station occasionally occurred.

We, therefore, decided to replace both types of TLD's with Harshaw TLD–100 LiF chips (natural lithium). This system was chosen because LiF exhibits negligible dosimeter background and fading characteristics, tissue equivalence, and uniform energy response. Although this system lacks the sensitivity of the CaF_2:Dy system, its fading and energy response characteristics are better. Increasing the high voltage on an Eberline TLR–5 reader produces approximately 60 net counts above a 20- to 25-count background for a 10-mR dose to the TLD's. This is approximately the dose received at a typical station in the TLD array.

Due to delays in acquisition, the TLD–100 chips were not available for placement in July. The operational necessity to field a set of TLD's to maintain continuity led to the placement of 55 Harshaw TLD–700 chips that were available for other purposes. Both TLD–700 and TLD–100 chips are LiF chips, but in this case the lithium is depleted in lithium-6. For comparison, 39 EG&G and 41 MBLE TLD's were placed with the TLD–700 chips, and the results of this placement are given in table 7. Continued acquisition delays led to further complications in August. Not enough TLD–700 chips were available to allow for placement of fresh TLD's while

Table 7. Thermoluminescent dosimeter readings, January-December 1971

Month	EG & G dosimeters				MBLE dosimeters				Harshaw			
	Offsite		Onsite		Offsite		Onsite		Offsite		Onsite	
	Number of stations	(mR/day)	Number of stations	(mR/day)	Number of stations	(mR/day)	Number of stations	(mR/day)	Number of stations	(mR/day)	Number of stations	(mR/day)
January	20	[a]0.50±0.13	37	0.53±0.13	20	0.20±0.12	37	0.21±0.12				
February	22	.44± .11	37	.52± .11	22	.20± .10	37	.21± .09				
March	21	.29± .11	36	.31± .09	21	.20± .10	37	.21± .12				
April	21	.20± .09	37	.28± .12	21	.18± .10	37	.21± .13				
May	22	.26± .10	35	.31± .09	22	.26± .12	37	.31± .15				
June	21	.24± .14	34	.31± .12	20	.22± .11	36	.24± .09				
July	12	.47± .07	27	.47± .05	13	.14± .07	28	.12± .04	23	0.12±0.03	33	0.14±0.01
August	23	.18± .05	31	.26± .07	23	.20± .04	31	.18± .03				

[a] Average and 95-percent confidence limits for the average.

reading those that had been in the field. Therefore MBLE and EG&G TLD's were again fielded in August, and the results of this placement also are given in table 7.

The Harshaw TLD–100 TLD's were finally put into service on August 25, 1971. The configuration of the station array was revised slightly to provide more uniform coverage.

Each station consists of three TLD chips in a single container. The TLD's are exchanged for fresh ones and read at 28-day intervals, and the average of the three readings for each station is taken to be the dose at that station for that period.

A summary of these measurements is given in table 8. There were five measurement intervals during the last part of the report period. Occasionally, a TLD package was missing at collection time causing the number of measurements to be less than five. Station 35 was discontinued during the report period but will be reinstated.

Table 8. Summary of thermoluminescent dosimeter readings, January-December 1971

Stations	Number of readings	Dose (mR)	
		Maximum	Average*
Offsite:			
1	5	12.1	10.1± 2.1
2	5	13.2	10.6± 2.7
3	5	13.1	10.2± 2.2
4	5	11.8	10.7± 1.8
5	5	12.0	10.8± .9
6	5	15.4	13.6± 2.5
7	5	10.9	9.8± 1.1
8	5	11.4	9.7± 1.5
9	5	15.6	11.4± 3.2
10	5	11.5	10.7± .8
11	5	17.2	14.2± 3.1
12	5	10.7	10.0± .6
13	4	10.3	8.5± 2.1
14	5	16.6	13.5± 2.6
15	5	11.6	10.3± 1.6
16	5	11.2	10.0± 1.2
17	5	11.9	10.4± 1.1
18	5	11.3	9.3± 1.6
19	4	11.4	8.8± 3.6
20	4	10.2	8.9± 2.1
21	5	11.6	10.5± 1.3
22	5	19.1	14.8± 3.5
Onsite:			
23	5	11.3	10.2± 1.0
24	5	16.5	13.6± 2.4
25	5	14.0	10.8± 3.5
26	5	12.7	11.0± 1.2
27	5	13.0	10.7± 2.0
28	3	12.9	11.4± 5.2
29	5	14.0	12.8± 1.6
30	5	12.2	10.5± 1.2
31	5	15.8	12.9± 2.3
32	5	13.7	12.5± 1.6
33	5	34.1	21.8±10.1
34	5	13.4	12.1± 1.6
35	1	15.9	—
36	5	14.9	12.9± 2.0
37	4	12.4	11.9± .5
38	5	16.2	15.0± 1.3
39	5	15.1	12.9± 2.9
40	5	12.5	10.9± 1.9
41	5	11.5	10.2± 2.2
42	5	12.0	10.9± 1.3
43	5	12.7	11.1± 2.1
44	5	16.5	13.6± 2.6
45	5	12.1	9.9± 2.6
46	5	12.9	11.4± 1.3
47	5	12.1	11.0± 1.6
48	5	13.7	11.2± 3.3
49	5	14.4	11.2± 3.4
50	4	11.2	10.1± 2.1
51	5	12.3	10.4± 1.5
52	5	11.9	11.0± 1.6
53	4	13.1	10.7± 3.3
54	5	15.5	12.5± 3.1
55	5	12.4	11.8± 1.2
56	5	12.3	10.8± 1.3
57	5	10.6	9.1± 2.0
58	5	13.3	10.7± 2.2

* Average and 95-percent confidence limits for the average.

In general, the TLD measured dose decreased over the 6-month period. The average for all offsite stations was 10.8 mR per 28-day interval, and the corresponding number for all onsite stations was 11.6 mR, neglecting station 33 (TA–18) whose response was due to the programmed operation of a fast burst reactor at TA–18. The readings for two offsite stations, number 11, Los Alamos Airport, and number 22, Bandelier Headquarters, and one onsite station, number 38 (TA–39), were slightly higher than the onsite and offsite averages. For comparison purposes, TLD-measured dose at Colorado Springs (6,170-foot elevation) for an equivalent period was about 11.3 mR and points closer to sea level (<1,000-foot elevation) were reported as 2 to 6 mR (*3*). The Los Alamos averages seem to be consistent with doses expected from solar radiation at this elevation.

Water monitoring

The water monitoring program is designed to provide for surveillance of the Los Alamos municipal water supply, which is drawn from the deep aquifer underlying the laboratory area, as well as for general surveillance of the ground and surface waters in the vicinity (figure 3).

Water samples are collected in new polyethylene bottles. For samples from wells other than supply wells, a sufficient quantity of water is drawn and discarded so that the sample is representative of the ground water at the time of sampling. Samples from supply wells are collected at the individual well heads during pumping. Samples of surface water are bailed from a convenient pool or allowed to flow directly into the sample container. All samples are analyzed by radiochemical methods for

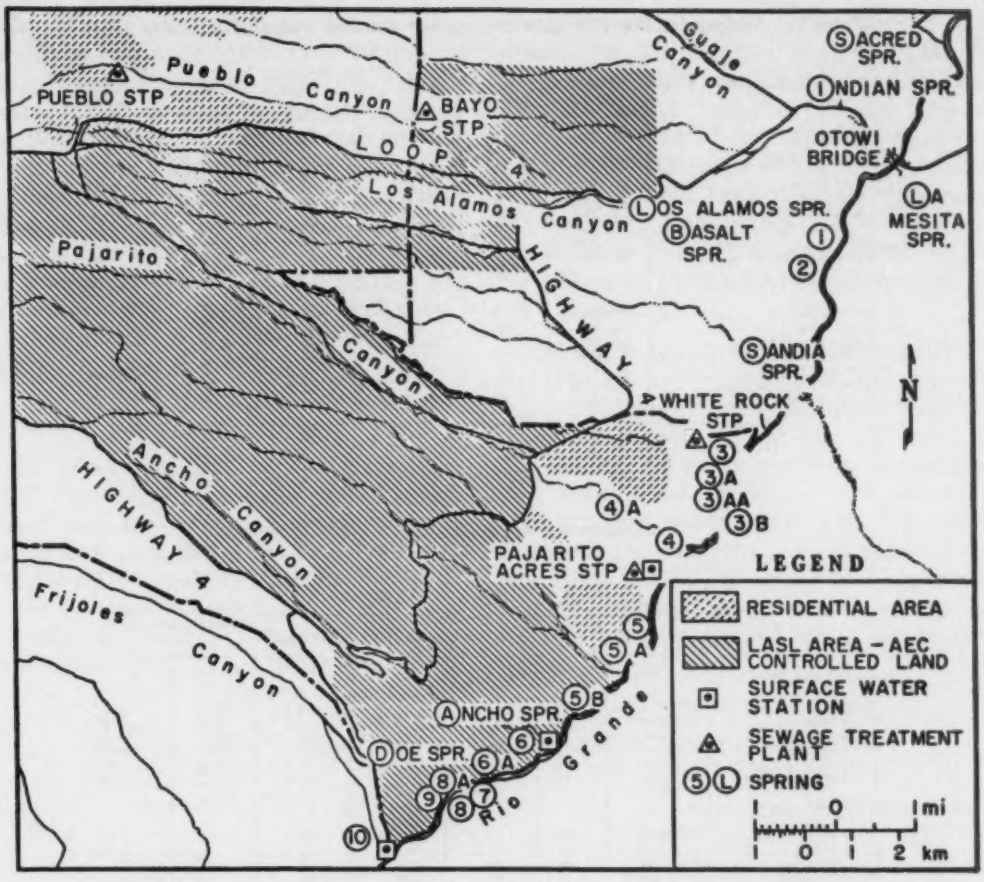

Figure 3. Locations of surveillance water sampling stations, Los Alamos

gross alpha, beta, and gamma emitters; tritium, plutonium-238, plutonium-239 and cesium-137. An analyses for radium or strontium are performed if such analyses are indicated by the gross alpha or gross beta measurements. A fluorometric technique is used to measure the concentration of uranium.

The plutonium determinations performed on these water samples deserve special mention since tenuous identifications of trace amounts of this material were made on several occasions. These identifications are believed to be due to cross-contamination in the analytical laboratory or to fluctuations of the MDL, both very real problems at the low concentrations being investigated here. Thus, those samples in which traces of plutonium were found are reported with the understanding that they probably are not indicative of actual plutonium contamination of the water from which they were taken. Verification will depend upon patterns established by analyses of future sample collections.

Los Alamos water supply

Samples of water were collected and analyzed in a continuing program to monitor the chemical and radiochemical quality of the municipal water supply at Los Alamos. This water is pumped from the 16 deep supply wells completed into the main aquifer and ranging in

Table 9. Analyses of Los Alamos water system samples, January-December 1971

Determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971:						
Gross alpha	pCi /liter	18	15	<2.0	2.0	2.0
Gross beta	pCi /liter	18	7.2	<2.0	3.0	2.0
Plutonium-238	fCi /liter	18	<50	<50	<50	50
Plutonium-239	fCi /liter	18	<50	<50	<50	50
Tritium	nCi /liter	18	<1.0	<1.0	<1.0	1.0
Total uranium	µg /liter	18	9.1	<.40	1.5	.40
July-December 1971:						
Gross alpha	pCi /liter	17	4.0	<1.0	<1.3	1.0
Gross beta	pCi /liter	17	<1.0	<1.0	<1.0	1.0
Plutonium-238	fCi /liter	17	<50	<50	<50	50
Plutonium-239	fCi /liter	17	<50	<50	<50	50
Cesium-137	nCi /liter	17	<.35	<.35	<.35	.35
Tritium	nCi /liter	17	<1.0	<1.0	<1.0	1.0
Total uranium	µg /liter	17	2.7	<.40	<.77	.40

Table 10. Analysis of water from regional sampling stations January-December 1971

Determination	Units	Number of samples	Range			Galisteo Reservoir	Detection limit
			Maximum	Minimum	Average		
January-June 1971:							
Gross alpha	pCi /liter	15	2.8	<2.0	2.0	<2.0	2.0
Gross beta	pCi /liter	15	12	<2.0	4.3	7.0	2.0
Plutonium-238	fCi /liter	15	<50	<50	<50	<50	50
Plutonium-239	fCi /liter	15	<50	<50	<50	<50	50
Tritium	nCi /liter	15	<1.0	<1.0	<1.0	<1.0	1.0
Total uranium	µg /liter	15	2.7	<.40	1.1	6.8	.40
July-December 1971:							
Gross alpha	pCi /liter	16	6.0	<1.0	<1.6		1.0
Gross beta	pCi /liter	16	6.0	<1.0	<3.1		1.0
Plutonium-238	fCi /liter	16	<50	<50	<50		50
Plutonium-239	fCi /liter	16	60	<50	<51		50
Cesium-137	nCi /liter	16	<.35	<.35	<.35		.35
Tritium	nCi /liter	16	<1.0	<1.0	<1.0		1.0
Total uranium	µg /liter	16	9.5	<.40	2.5		.40

depth from 870 to 2,600 feet. One spring on the eastern flanks of the Jemez Mountains has been developed and also contributes to the water supply. About 5 billion gallons of water were supplied to the Los Alamos complex during 1971. Additional data were obtained from two test wells which also are completed into the main aquifer. The range and average of constituents in the water from the 16 supply wells and the 2 test wells are shown in table 9.

These results indicate no significant change in the water quality during this reporting period as compared to previous analyses. The maximum concentrations were all well below the limits defined by the U.S. Public Health Service standards for drinking water (4) and the concentration guides for radioactive materials as given in AEC Manual Chapter 0524.

Regional surface water

Offsite rivers and reservoirs in and adjacent to the Los Alamos areas are sampled and analyzed on a routine basis to provide information on general water quality in the area and to serve as background for other measurements. During this period, 8 water samples were collected from 4 rivers, the Rio Chama at Chamita and the Rio Grande at Embudo, Otowi and Cochiti. In addition, 8 samples were taken

from the following bodies of water: the Caliente River, Santa Cruz Reservoir, Galisteo Reservoir, the Rio Grande at Bernalillo, Jemez Reservoir, Jemez Creek, Fenton Lake, and Abiquiu Reservoir. The range and average of constituents of water from these sampling stations is shown in table 10. It should be noted that the quantity of water from those sources is subject to drastic fluctuations due to variations in discharge and in size and terrain of the drainage area. The analysis of the water taken from the Rio Grande at Embudo indicated a trace of plutonium-239.

General water surveillance

Samples of sewage, effluent, surface water, shallow ground water and water from nearby reservoirs used for irrigation were collected and analyzed to help assess the overall impact of the laboratory operations on the environment.

The range and average of constituents in sewage effluent from four offsite municipal sewage treatment ponds and lagoons is shown in table 11. The positive value of 70 fCi/liter for plutonium-239 was detected in the sample from the Pueblo Treatment Plant. This is a very low value and is probably due to contamination in the handling of the sample prior to or during analysis. Trace amounts of plutonium-238 were reported in one sample each from the Rock Sewage Treatment Plant and the Bayo Sewage Treatment Plant, 60 and 80 fCi/liter, respectively.

The range and average of the measurements on water samples from four streams, two reservoirs, two springs, and two observation holes are given in table 12 for January–June 1971. The results of the measurements on water samples indicate no anomalies. The observation holes are shallow penetrations into the alluvium underlying the canyons and the samples represent water which has seeped into the alluvium and is essentially static. Three of the intermittent flow stations and one observation hole are onsite.

Table 11. Analysis of effluents from sewage treatment plants, January-December 1971

Determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971:						
Gross alpha	pCi/liter	4	<2.0	<2.0	<2.0	2.0
Gross beta	pCi/liter	4	40	12	27	2.0
Plutonium-238	fCi/liter	4	<50	<50	<50	50
Plutonium-239	fCi/liter	4	70	<50	60	50
Tritium	nCi/liter	4	<1.0	<1.0	<1.0	1.0
Total uranium	µg/liter	4	2.0	.60	.90	.40
July-December 1971:						
Gross alpha	pCi/liter	8	2	<1.0	<1.0	1.0
Gross beta	pCi/liter	8	37	2	12	1.0
Plutonium-238	fCi/liter	8	80	<50	<55	50
Plutonium-239	fCi/liter	8	<50	<50	<50	50
Cesium-137	nCi/liter	4	<.35	<.35	<.35	.35
Tritium	nCi/liter	8	13	<1.0	<2.5	1.0
Total uranium	µg/liter	8	<1.8	<.40	<1.1	.40

Table 12. Analysis of water from stream, reservoir, spring and observation hole surveillance stations, January-June 1971

Constituent	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
Offsite stations:						
Gross alpha	pCi/liter	6	2.4	<2.0	2.0	2.0
Gross beta	pCi/liter	6	2.3	<2.0	2.1	2.0
Plutonium-238	fCi/liter	6	<50	<50	<50	50
Plutonium-239	fCi/liter	6	<50	<50	<50	50
Tritium	nCi/liter	6	<1.0	<1.0	<1.0	1.0
Total uranium	µg/liter	6	1.4	<.40	.70	.40

Table 13. Analyses of offsite ground water, July-December 1971

Determination	Unit	Los Alamos Spring	Basalt Spring	Detection level
Gross alpha	pCi/liter	<1.0	<1.0	1.0
Gross beta	pCi/liter	<1.0	<1.0	1.0
Plutonium-238	fCi/liter	<50	<50	50
Plutonium-239	fCi/liter	<50	<50	50
Cesium-137	nCi/liter	<.35	<.35	.35
Tritium	nCi/liter	<1.0	<1.0	1.0
Total uranium	μg/liter	.60	1.8	.40

Table 14. Analysis of offsite surface and ground water from the White Rock Canyon, July-December 1971

Determination	Unit	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
Gross alpha	pCi/liter	19	6.0	<1.0	<1.5	1.0
Gross beta	pCi/liter	19	2.5	<1.0	<1.1	1.0
Plutonium-238	fCi/liter	19	70	<50	<51	50
Plutonium-239	fCi/liter	19	50	<50	<50	50
Cesium-137	nCi/liter	19	<.35	<.35	<.35	.35
Tritium	nCi/liter	19	<1.0	<1.0	<1.0	1.0
Total uranium	μg/liter	19	13.0	<.40	<1.8	.40

Samples from two surveillance surface and ground water stations—(Los Alamos Spring and Basalt Spring) are collected semiannually. The results of the analyses of these samples are given in table 13 for July–December 1971. No results were abnormal for these stations.

A group of samples collected only on a biennial basis consists of water samples collected from 24 spring and 3 stream stations in the White Rock Canyon of the Rio Grande. These springs and streams are perennial with most of the water discharging from the main aquifer from which the municipal water supply is drawn.

The range and average of constituents in water from offsite stations at 17 springs and 2 streams in the White Rock Canyon are shown in table 14 for July–December 1971. Spring 3, a highly mineralized spring issuing from a fault line on the east bank of the river, is responsible for several of the reported maximum values. Its natural uranium concentrations are much higher than in water from the other stations. Spring 1 is a seep area more than an acre in extent, and the sample was collected near its discharge into the river. Traces of plutonium-238 and plutonium-239 were found for the first time in water from this source.

Sediments

Sediments are those earthen materials which have been transported and reworked by surface water. Samples are collected at the 40-50 km distant stations from which regional surface water samples were obtained. In addition, samples are taken for general surveillance from stream beds in the canyons in the vicinity of the laboratory. Some of these streams occur naturally and may flow perennially or intermittently during the rainy season. Some are streams produced by effluents from laboratory or municipal facilities.

Sediment samples from perennial streams are taken from dunes built up in eddies behind boulders in the main channel. In still water, the samples are dredged from the bottom with a bailer at some convenient point. From the intermittent streams, the samples are collected across the main channel to a 1-inch depth with a 3-inch scoop. The samples are placed in unused polyethylene containers for storage and transport to the laboratory. The samples are leached with acids and determinations of gross alpha emitters, gross beta emitters, plutonium and uranium are made on the acid leach. Strontium analyses are performed if the gross beta activity is high.

Table 15. Analyses of regional sediment samples, January-December 1971

Determination	Unit	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971:						
Gross alpha	pCi/g	9	8.6	1.1	3.4	1.0
Gross beta	pCi/g	9	6.7	1.1	3.5	1.0
Plutonium-238	fCi/g	9	3.0	<1.0	1.7	1.0
Plutonium-239	fCi/g	9	5.0	1.0	3.1	1.0
Total uranium	ng/g	9	130	<10	52	10
July-December 1971:						
Gross alpha	pCi/g	8	5.0	2.0	3.0	1.0
Gross beta	pCi/g	8	3.0	1.0	2.0	1.0
Plutonium-238	fCi/g	8	3.0	1.0	2.0	1.0
Plutonium-239	fCi/g	8	4.0	2.0	2.0	1.0
Cesium-137	fCi/g	8	200	200	200	200
Total uranium	ng/g	8	310	70	190	10

Sediments were collected and analyzed from the regional surface water sampling stations to provide general data on the quantities of radioactive materials in the environment beyond the general laboratory area. The results of the analyses are given in table 15.

Sediments for general surveillance

The results of the analyses of onsite and offsite samples are given in table 16. In general, the results for these sediment samples appear to be about as expected. Concentrations of plutonium lie in the range expected from fallout with the exception of the five samples taken from Pueblo, Los Alamos, and Mortandad Canyons.

The area from which the two Pueblo Canyon samples were taken is known to have trace amounts of plutonium as a result of earlier releases of industrial effluents into Acid Canyon, a tributary to Pueblo Canyon, a short distance above these sampling points. These effluents were released from 1949 through 1962, and the treatment plant has since been dismantled. The results of this program are in agreement with and confirm values reported earlier for this region (*5*).

The two positive Los Alamos Canyon samples also were from an area known to contain small quantities of this material washed down the canyon from effluent disposal operations in DP Canyon, which is tributary to Los Alamos Canyon several miles upgrade. The concentrations measured essentially are the same as those reported earlier (*5*).

The positive Mortandad Canyon sample reflects operations at the central liquid waste treatment plant at TA–50, which discharges liquid effluent into Effluent Canyon, a tributary to Mortandad Canyon, a short distance upstream of the sample collection station. Again, the values reported here agree with those reported earlier (*5*).

One onsite sample exhibited an unusually high uranium concentration, reflecting the fact that it was collected in an area where explosive tests had dispersed uranium.

Soils

Soils are those earthen materials that are weathered in place. They are sampled primarily to indicate the possibility of deposition of contaminants from the atmosphere. Samples are collected by taking five plugs, 3 inches in diameter and 2 inches deep, at the corners and center of a square 10 meters on a side. The five plugs are composited into a single sample and analyzed for gross alpha and beta radioactivity, plutonium, cesium, tritium, and uranium, using basically the same techniques as for sediment samples. Samples are taken at the regional surface water stations and at stations established for general surveillance in the vicinity of Los Alamos.

A summary of the results from the samples taken at distances of 40 to 50 km from the center of the laboratory area is given in table 17. The values are in line with those expected from natural radioactivity and fallout from past weapons tests (*6*).

Table 16. Analysis of sediments collected for general surveillance January-December 1971

Sample determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971:						
Offsite stations:						
Gross alpha	pCi/g	5	7.4	1.2	3.2	1.0
Gross beta	pCi/g	5	3.7	1.9	2.6	1.0
Plutonium-238	fCi/g	5	16	1.0	4.8	1.0
Plutonium-239	fCi/g	[a] 4	9.0	2.0	4.8	1.0
Total uranium	ng/g	5	190	70	130	10
Onsite stations:						
Gross alpha	pCi/g	7	6.3	1.1	2.5	1.0
Gross beta	pCi/g	7	31	<1.0	5.9	1.0
Plutonium-238	fCi/g	[b] 6	7.0	<1.0	4.3	1.0
Plutonium-239	fCi/g	[c] 3	6.0	<1.0	2.6	1.0
Total uranium	ng/g	5	810	70	250	10
July-December 1971:						
Offsite stations:						
Gross alpha	pCi/g	4	5.0	2.0	3.0	1.0
Gross beta	pCi/g	4	18.0	1.0	6.0	1.0
Plutonium-238	fCi/g	4	1.0	<1.0	<1.0	1.0
Plutonium-239	fCi/g	4	4.0	1.0	4.0	1.0
Cesium-137	fCi/g	4	<200	<200	<200	200
Total uranium	ng/g	4	80	20	50	10
Onsite stations:						
Gross alpha	pCi/g	2	11	5.0	8.0	1.0
Gross beta	pCi/g	2	8.0	4.0	6.0	1.0
Plutonium-238	fCi/g	2	5.0	<1.0	<3.0	1.0
Plutonium-239	fCi/g	2	7.0	1.0	4.0	1.0
Cesium-137	fCi/g	2	<200	<200	<200	200
Total uranium	ng/g	2	2,790	150	1,470	10

[a] Does not include one sample from Pueblo Canyon which gave 2.9 pCi/g.
[b] Does not include one sample from Mortandad Canyon which gave 1.6 pCi/g.
[c] Does not include one sample from Pueblo Canyon which gave 0.8 pCi/g, two samples from Los Alamos Canyon which gave 1.0 and 0.1 pCi/g, and one sample from Mortandad Canyon which gave 1.1 pCi/g.

A summary of the results from the samples taken in the vicinity of Los Alamos County is given in table 18.

The values found are again in general agreement with those expected from natural activity and fallout from past weapons tests with the exception of two samples. These two samples, which were high in plutonium, were taken from areas known to be contaminated from airborne effluents.

Discussion

The results of the monitoring program for this period confirm the generally low radiation levels in the Los Alamos environs as noted in previous periods. Measurements of the gross activities in air and precipitation indicate concentrations similar to those measured at other locations in the northern hemisphere where activity is entirely attributable to the presence of worldwide fallout. Isotopic measurements of iodine, plutonium, and tritium in the atmosphere show that the iodine concentrations are below the detection limit; that there are places where the plutonium concentrations may be somewhat above that expected from past weapons testing; and that some of the offsite concentrations of tritium appear to be about twice that encountered at locations distant from the laboratory.

In the following discussion we will use the concept of "dose commitment", the total radiation dose received by an individual during his remaining lifetime due to operations during this report period. For radionuclides with long effective half-lives (physical and biological) the length of the remaining lifetime must be considered. This length has arbitrarily been set as 50 years for the purposes of this report. For an element with an effective half-life considerably less than 50 years, by far the greatest part of the dose is contributed during the first few years, so that the length of the accumulation period is unimportant so long as it is longer than several half-lives. We thus speak merely of a "dose commitment" rather than a "50-year dose commitment." Furthermore, for an element with an effective half-life very short com-

Table 17. Analysis of soils in vicinity of regional surface waters January-December 1971

Determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971						
Gross alpha	pCi/g	10	6.3	<1.0	3.3	1.0
Gross beta	pCi/g	10	9.2	3.1	5.2	1.0
Plutonium-238	fCi/g	10	11	<1.0	2.7	1.0
Plutonium-239	fCi/g	10	25	3.0	10	1.0
Total uranium	ng/g	10	310	80	190	10
July December 1971						
Gross alpha	pCi/g	9	10	2.0	5.0	1.0
Gross beta	pCi/g	9	10	4.0	6.0	1.0
Plutonium-238	fCi/g	9	5.0	1.0	3.0	1.0
Plutonium-239	fCi/g	9	20	3.0	10	1.0
Cesium-137	fCi/g	9	300	<200	<200	200
Tritium[a]	nCi/liter	9	9.0	<2.0	<4.0	2.0
Total uranium	ng/g	9	500	40	230	10

[a] Soil moisture distilled from sample.

Table 18. Analysis of soils taken for general surveillance, January-December 1971

Determination	Units	Number of samples	Range			Detection limit
			Maximum	Minimum	Average	
January-June 1971						
Offsite stations:						
Gross alpha	pCi/g	4	4.6	3.9	4.1	1.0
Gross beta	pCi/g	4	5.7	4.8	5.1	1.0
Plutonium-238	fCi/g	4	2.0	<1.0	1.5	1.0
Plutonium-239	fCi/g	4	15	7.0	12	1.0
Total uranium	ng/g	4	490	330	380	10
Onsite stations:						
Gross alpha	pCi/g	4	5.0	2.8	3.8	1.0
Gross beta	pCi/g	4	7.0	4.5	5.6	1.0
Plutonium-238	fCi/g	4	3.0	<1.0	1.8	1.0
Plutonium-239	fCi/g	[a] 2	18	12	15	1.0
Total uranium	ng/g	3	840	660	770	10
July-December 1971						
Offsite stations:						
Gross alpha	pCi/g	3	8.0	6.0	7.0	1.0
Gross beta	pCi/g	3	6.0	5.0	6.0	1.0
Plutonium-238	fCi/g	3	5.0	2.0	4.0	1.0
Plutonium-239	fCi/g	3	36	7.0	19	1.0
Cesium-137	fCi/g	3	<200	<200	<200	200
Tritium [b]	nCi/liter	3	14	13	3	2.0
Total uranium	ng/g	3	330	220	260	10
Onsite stations:						
Gross alpha	pCi/g	2	6.0	6.0	6.0	1.0
Gross beta	pCi/g	2	7.0	6.0	6.0	1.0
Plutonium-238	fCi/g	2	10	1.0	5.0	1.0
Plutonium-239	fCi/g	2	25	20	22	1.0
Cesium-137	fCi/g	2	<200	<200	<200	200
Tritium [b]	nCi/liter	2	15	14	14	2.0
Total uranium	ng/g	2	500	200	350	10

[a] Does not include one sample from TA-21 which gave 220 fCi/g and one from near TA-50 which gave 110 fCi/g.
[b] Soil moisture distilled from soil sample.

pared to 50 years, the dose is received substantially instantaneously, and it is sufficient to use the more familiar concept of dose rather than dose commitment.

Using the constants listed in the 1959 ICRP internal dose report (*7*), the highest offsite plutonium-238 concentration was sufficient to produce, during the report period, a dose com-

mitment for the lungs of about 0.06 mrem assuming all of the material to be insoluble. Alternately, assuming all of the material to be soluble (20 percent transferred to bone, a quality factor of 10 and a "non-uniform distribution factor" of 5), the 50-year dose commitment to bone was about 1.9 mrem. The actual dose commitment would lie somewhere between these two. In comparison, the guide value from AEC Manual Chapter 0524 for the dose commitment for bone or lungs is 1,500 mrem for an individual or 500 mrem for a suitable sample of the population. The plutonium-239 results show no significant difference between stations indicating that the source is probably worldwide fallout. This source (averaged over all offsite stations) contributed an estimated dose commitment of about 0.09 mrem to the lungs or 3.4 mrem to bone.

During the reporting period, the average offsite tritium concentration in the Los Alamos area was sufficient to produce a whole body dose of about 0.22 mrem, using the quality factor of 1.7, used in the derivation of the 1960 ICRP-NCRP maximum permissible concentrations that apparently served as the basis for the AEC Manual Chapter 0524 concentration guides. If the quality factor of 1.0 now accepted by the ICRP and NCRP is used for these low energy beta radiations, this dose is about 0.13 mrem. This may be compared with the radiation protection guide for annual dose to the whole body given in AEC Manual Chapter 0524 of 500 mrem for an individual or 170 mrem for a suitable sample of the population.

External gamma and x-radiation levels, as measured by thermoluminescent dosimeters, were comparable to those measured elsewhere at approximately the same elevation. This suggests that the predominant contribution to external dose is from solar radiation.

The Los Alamos water supply remained uninfluenced by laboratory operations. Traces of plutonium have been tenuously identified in offsite samples collected from bodies of surface water, sewage effluent, and, in one instance, ground water. These identifications are believed to be due to cross-contamination in the laboratory, a very real problem when dealing with such low levels.

Small quantities of plutonium and some beta emitters were found in sediment collected in several of the offsite canyons, resulting from past disposal operations. These locations, while accessible to the public, are reasonably isolated so that occupancy is limited to an occasional hiker or hunter. It is impossible to estimate a possible dose or dose commitment from these deposits; the low occupancy factor and the association of the material with large quantities of sediment should preclude the uptake of any significant quantities by people, animals, or plants.

Summary

Results of the environmental monitoring program at the Los Alamos Scientific Laboratory for January through December 1971 are given. The program is in the process of change in order to better satisfy the needs for environmental data at very low levels. Results for this period indicate no significant changes from those for previous periods. Concentrations of plutonium-238 above that expected from worldwide fallout were measured at several stations including one offsite station. The 50-year dose commitment resulting from 6 months exposure at this station is estimated to be less than 0.04 mrem for the lungs or 2 mrem for the bone as compared to the annual radiation protection guide value given in AEC Manual Chapter 0524 of 1,500 mrem for an individual or 500 mrem for a suitable sample of the population. Tritium concentrations in the atmosphere appear to be elevated in the Los Alamos area and may have contributed a whole-body dose of about 0.1 mrem during the report period as compared to the annual guide value of 500 mrem for an individual or 170 mrem for a suitable sample of the population.

Areas with trace contamination by plutonium and beta emitters are present in canyons now used or previously used for disposal of liquid effluents. These are unoccupied areas and present no problems in terms of radiation exposure. Small quantities of plutonium also appear in the soils around the plutonium fabrication facility (TA-21) as a result of past deposition from airborne effluents. Again, the quantities are small and there is no indication of an ele-

vated air concentration which is the hazard of concern since inhalation is believed to be the main route of plutonium entry into the body.

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Reported Nuclear Detonations, October 1973

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission conducted an underground nuclear test at its Nevada Test Site on October 12, 1973. The test was in the low yield range of less than 20 kilotons.

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on October 26, 1973. The signals originated at approximately 12 a.m. EDT, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

Seismic signals presumably from a Soviet underground nuclear test in the yield range of less than 20 kilotons were recorded by the United States on October 26, 1973 at about 2:00 a.m. EDT. The signals originated in the southern Ural area of the Soviet Union.

Seismic signals from a large Soviet underground nuclear test were recorded by the United States on October 27, 1973. The signals originated at approximately 3 a.m. EDT, in southern Novaya Zemlya in the Arctic. This test was about the same size as the one on September 12, 1973, which was announced as 3 to 6 megatons.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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EVALUATION OF URANIUM MINE ATMOSPHERES BY MEASUREMENTS OF THE WORKING LEVEL AND RADON. *Duncan A. Holaday* and *James H. Jones. Radiation Data and Reports, Vol. 14, November 1973*, pp. 653–657.

Using estimates of equilibrium ratios and concentrations of unattached atoms in uranium mines, calculations were performed and results presented of the amount of alpha energy per liter of air per working level available to be imparted to the various regions of the respiratory tract. It was discovered that the factor that caused the greatest effect on the alpha energy that could be deposited in the lungs was a change in the unattached fraction of the radon daughters. If the radon concentration was used to determine potential exposure, radon to daughter ratios also had a marked effect on the potential alpha energy deposition.

KEYWORDS: Alpha energy deposition, mines, radon, radon daughters, uranium.

RADIOLOGICAL SURVEY OF NEW LONDON HARBOR, THAMES RIVER, CONN. AND ENVIRONS. *Sam T. Windham* and *Charles R. Phillips. Radiation Data and Reports, Vol. 14, November 1973*, pp. 659–666.

The Eastern Environmental Radiation Laboratory, in cooperation with the U.S. Naval Ship Systems Command, conducted a radiological survey of the New London Harbor, Thames River and environs to determine if nuclear ship activity in that area has contributed radioactivity which could contribute detectable radiation exposure to the public. Comparison with a similar survey conducted in 1966 show that activity levels in sediment have decreased by an average factor of 33 due to a reduction in the amount of radioactivity discharged, radioactive decay and natural sedimentation. Analysis of samples indicative of direct pathways for human exposure lead to the conclusion that no significant radiation exposure to the public has resulted from nuclear ship operations in this area. It is concluded that the environmental surveillance routinely conducted by the Navy should be adequate to assure protection of the public from the routine nuclear ship operations.

KEYWORDS: Connecticut, environmental radioactivity, harbor survey, nuclear ships.

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